Curriculum

The following description is followed.

C - Core Modules

E - Elective Modules

Code	Module Name	Category	Hours/Week Lecture	Hours/Week Lab/Tute	Credits GPA	Credits NGPA	Norm GPA	Norm NGPA	Evaluation CA%	Evaluation WE%
Semester 1		**Specialization requirement**					**15.0**			
CE1023	Fluid Mechanics	C	2	2/4	2.0				20	80
CS1033	Programming Fundamentals	C	2	2	2.0				20	80
EE1040	Electrical Fundamentals	C	2	2/4	3.0				20	80
MA1014	Mathematics	C	5/2	1	3.0		15.0		20	80
ME1033	Mechanics	C	2	2/4	2.0				20	80
MT1023	Properties of Materials	C	2	2/4	2.0				20	80
EL1030	Language Skills Enhancement [S1 & S2]	C	0	2	1.0				100	0
				Total for semester 1	**15.0**	**0.0**	**15.0**	**0.0**		
Semester 2		**Specialization requirement**					**20.0**			
CH1051	Engineering Thermodynamics	C	2	2	3.0				40	60
CH1044	Fluid Dynamics	C	3	2	4.0				40	60
CH1071	Chemistry and Green Chemistry for Process Engineers	C	2	2	3.0		18.0		40	60
CH1061	Chemical and Bioprocess Engineering Principles	C	3	2	4.0				40	60
MA1024	Methods of Mathematics	C	5/2	1	3.0				30	70
EL1030	Language Skills Enhancement [S1 & S2]	C	0	2	1.0				100	0
HM-1	Humanities I	E	2	0	2.0		2.0		100	0
				Total for semester 2	**20.0**	**0.0**	**20.0**	**0**		

Code	Module Name	Category	Hours/Week: Lecture	Hours/Week: Lab/Tute	Credits: GPA	Credits: NGPA	Norm: GPA	Norm: NGPA	Evaluation: CA%	Evaluation: WE%
Semester 3		**Specialization requirement**					**20.0**			
CH2631	Chemical Thermodynamics	C	2	2	3.0		20.0		40	60
CH2015	Heat and Mass Transfer	C	3	2	4.0				40	60
CH2160	Bioprocess Engineering and Practices	C	2	2	3.0				40	60
CH2170	Laboratory Practices I	C	0	6	3.0				100	0
MA2014	Differential Equations	C	2	0	2.0				30	70
MA2034	Linear Algebra	C	2	0	2.0				30	70
EN1803	Basic Electronics for Engineering Applications	C	2	2	3.0				30	70
	Total for semester 3				**20.0**	**0.0**	**20.0**	**0.0**		
Semester 4		**Specialization requirement**					**22.0**			
CH2151	Particulate Systems	C	3	2	4.0		20.0		40	60
CH2180	Separation Processes	C	3	4	5.0				40	60
CH4501	Chemical Kinetics and Reactor Design	C	3	2	4.0				40	60
CH2210	Materials for Engineering Applications	C	2	2	3.0				30	70
CH2270	Laboratory Practices II	C	0	4	2.0				100	0
MA3024	Numerical Methods	C	2	0	2.0				30	70
HM-2	Humanities II	E	2	0	2.0		2.0		100	0
	Total for semester 4				**22.0**	**0.0**	**22.0**	**0**		

Semester 5		Specialization requirement					23.0			
Code	Module Name	Category	Hours/Week Lecture	Hours/Week Lab/Tute	Credits GPA	Credits NGPA	Norm GPA	Norm NGPA	Evaluation CA%	Evaluation WE%
CH4045	Process Dynamics and Control	C	2	2	3.0				40	60
CH3045	Plant Safety, Health and Environment	C	7/2	1	4.0				30	70
CH3034	Process Equipment Design	C	3	2	4.0				40	60
CH3055	Energy Systems Engineering	C	2	2	3.0		21		40	60
CH3150	Chemical Process Synthesis and Integration	C	2	2	3.0				40	60
CH3880	Engineer and Society [S5 & S6	C	0	2	1.0				100	0
MN3043	Business Economics and Financial Accounting	C	3	0	3.0				30	70
MA3014	Applied Statistics	E	2	0	2.0				30	70
MA2024	Calculus	E	2	0	2.0		2		30	70
MA3030	Operational Research	E	2	0	2.0				30	70
Total for semester 5					**27.0**	**0.0**	**23.0**	**0.0**		
Industrial Training		**Specialization requirement**					**6.0**			
CH3994	Industrial Training	C				6.0		6.0	100	0
Total for Industrial Training						**6.0**	**0.0**	**6.0**		
Semester 6		**Specialization requirement**					**9.0**			
EL3820	Technical Report Writing and Presentation Skills	C	1	4	3.0				100	0
CH4751	Research Project [S6, S7 & S8]	C	0	2	1.0		9.0		100	0
CH3170	Laboratory Practices III	C	0	6	3.0				100	0
CH3880	Engineer and Society [S5 & S6]	C	1	2	2.0				100	0
Total for semester 6					**9.0**	**0.0**	**9.0**	**0.0**		

Semester 7		Specialization requirement					13.0			
Code	Module Name	Category	Hours/Week		Credits		Norm		Evaluation	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA%	WE%
CH4016	Comprehensive Design Project I	C	0	8	4.0		7.0		100	0
CH4751	Research Project [S6, S7 & S8]	C	0	2	1.0				100	0
MN4023	Engineering Economics	C	2	0	2.0				30	70
CH4120	Biofuels and Biorefineries	E	2	2	3.0		3.0		40	60
CH4130	Process Optimization	E	2	2	3.0				40	60
CH4140	Biotechnology	E	2	2	3.0				40	60
CH4160	Process Chemicals Management	E	2	2	3.0				40	60
CH4371	Petroleum Trade and Economics	E	2	2	3.0				30	70
CH4410	Polymeric Materials	E	2	2	3.0		3.0		30	70
CH4026	Process Modelling and Simulation	E	2	2	3.0				40	60
CH4420	Waste Minimization and Resources Recovery	E	2	2	3.0				30	70
CH4430	Industrial Chemical Manufacturing Processes	E	2	2	3.0				40	60
CH4235	Polymer Processing Operations	E	2	2	3.0				30	70
CH3720	Waste to Energy	E	2	2	3.0				40	60
CH3253	Environmental Bioengineering	E	2	2	3.0				30	70
CH4440	Petrochemical Process Operations	E	2	2	3.0				30	70
CH4285	Food Safety and Hygienic Plant Design	E	2	2	3.0				40	60
Total for semester 7					49.0	0.0	13.0	0.0		

Semester 8		Specialization requirement					10.0			
Code	Module Name	Category	Hours /Week		Credits		Norm		Evaluation	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA%	WE%
CH4035	Comprehensive Design Project II	C	0	10	5.0		10.0		100	0
CH4751	Research Project [S6, S7 & S8]	C	0	2	1.0				100	0
MN4151	Project Management	C	2	0	2.0				30	70
MN4113	Production and Operations Management	C	2	0	2.0				30	70
CH4275	Polymer Products Manufacturing Technologies	E	2	2	3.0				40	60
CH4742	Polymer Products and Tool Design	E	2	2	3.0				40	60
CH4450	Energy Storage Systems	E	2	2	3.0				40	60
CH4255	Renewable Energy	E	2	2	3.0				40	60
CH4651	Combustion Technology	E	2	2	3.0				40	60
CH4215	Environmental Engineering and Management	E	2	2	3.0				30	70
CH4460	Sustainable Process Technology	E	2	2	3.0				30	70
CH4351	Up-stream Oil and Gas Operations	E	2	2	3.0				30	70
CH4381	Petroleum Refining Operations	E	2	2	3.0				30	70
CH4294	Bioengineering	E	2	2	3.0				40	60
CH4691	Food Process Engineering	E	2	2	3.0				40	60
Total for semester 8					**43.0**	**0.0**	**10.0**	**0.0**		
		Grand total			**205.0**	**6.0**	**132.0**	**6.0**		

Focus Area

Code	Module Name	Category	Hours/ Week		Credits		Evaluation		Semester	Credits required
			Lecture	Lab/Tute	GPA	NGPA	CA%	WE%		
Focus area-Polymer Engineering										
CH4410	Polymeric Materials	C	2	2	3		30	70	7	12
CH4235	Polymer Processing Operations	C	2	2	3		30	70	7	
CH4275	Polymer Products Manufacturing Technologies	C	2	2	3		40	60	8	
CH4742	Polymer Products and Tool Design	C	2	2	3		40	60	8	
Focus area - Food and Bioengineering										
CH4140	Biotechnology	C	2	2	3		40	60	7	12
CH4285	Food Safety and Hygienic Plant Design	C	2	2	3		40	60	7	
CH4294	Bioengineering	C	2	2	3		40	60	8	
CH4691	Food Process Engineering	C	2	2	3		40	60	8	
Focus area - Environmental Engineering										
CH4420	Waste Minimization and Resources Recovery	C	2	2	3		30	70	7	12
CH3253	Environmental Bioengineering	C	2	2	3		30	70	7	
CH4215	Environmental Engineering and Management	C	2	2	3		30	70	8	
CH4460	Sustainable Process Technology	C	2	2	3		30	70	8	
Focus area - Petroleum Engineering										
CH4371	Petroleum Trade and Economics	C	2	2	3		30	70	7	12
CH4440	Petrochemical Process Operations	C	2	2	3		30	70	7	
CH4351	Up-stream Oil and Gas Operations	C	2	2	3		30	70	8	
CH4381	Petroleum Refining Operations	C	2	2	3		30	70	8	
Focus area - Energy Engineering										
CH4120	Biofuels and Biorefineries	C	2	2	3		40	60	7	9
CH3720	Waste to Energy	C	2	2	3		40	60	7	
CH4450	Energy Storage Systems	C	2	2	3		40	60	7	
CH4255	Renewable Energy	E	2	2	3		40	60	8	3
CH4651	Combustion Technology	E	2	2	3		40	60	8	

Minors

Students following the Chemical and Process Engineering program can obtain minors in by fulfilling following subject requirements.

Minor in English Literature

Code	Module Name	Category	Hours/ Week		Credits		Evaluation		Semester	Credits required
			Lecture	Lab/Tute	GPA	NGPA	CA%	WE%		
EL2410	Introduction to Literary Criticism	E	3		3.0		100		3	3
EL2420	Introduction to Poetry and Drama	E	3		3.0		100		4	9
EL3410	Contemporary South Asian Writing	E	3		3.0		100		5	
EL4410	Literature and Translation	E	3		3.0		100		7	
EL4420	Science Fiction: Cyborgs and Dystopia	E	3		3.0		100		8	
Total										**12**

Minor in English for Academic and Professional Purposes

Code	Module Name	Category	Hours/ Week		Credits		Evaluation		Semester	Credits required
			Lecture	Lab/Tute	GPA	NGPA	CA%	WE%		
EL2510	Academic Writing for Engineering Studies	E	3		3.0		100		3	12
EL2520	Technical Report Writing for Engineering Studies	E	3		3.0		100		4	
EL3510	Professional Communication for Engineering Contexts	E	3		3.0		100		5	
EL4510	Research Communication for Engineering Studies	E	3		3.0		100		7	
EL4520	Journalism and Journalistic Writing	E	3		3.0		100		8	
Total										**12**

Minor in Mathematics

Code	Module Name	Category	Hours/ Week		Credits		Evaluation		Semester	Credits required
			Lecture	Lab/Tute	GPA	NGPA	CA%	WE%		
MA2014	Differential Equations	C	2		2.0		30	70	3	2
MA2024	Calculus	C	2		2.0		30	70	3,5	2
MA2034	Linear Algebra	C	2		2.0		30	70	3,4	2
MA3014	Applied Statistics	C	2		2.0		30	70	3,4,5	2
MA3024	Numerical Methods	C	2		2.0		30	70	3,4,5	2
Electives for Statistics Minor										
MA4014	Linear Models and Multivariate Statistics	E	3		3.0		30	70	7,8	3
MA4090	Mathematical Statistics	E	3		3.0		30	70	7,8	
MA4034	Time Series and Stochastic Process	E	3		3.0		30	70	7,8	
MA4000	Experimental Design and Quality Control	E	3		3.0		30	70	7,8	
Electives for Mathematics Minor										
MA4110	Finite Element Analysis	E	3		3.0		30	70	7,8	3
MA4120	Advanced Differential Equations	E	3		3.0		30	70	7,8	
MA4130	Optimization	E	3		3.0		30	70	7,8	
MA4144	Neural Networks and Fuzzy Logic	E	3		3.0		30	70	7,8	
MA4150	Financial Mathematics	E	3		3.0		30	70	7,8	
MA4160	Advanced Operational Research	E	3		3.0		30	70	7,8	
MA4210	Mathematical Analysis and Special Functions	E	3		3.0		30	70	7,8	
MA4220	Topics in Algebra and Topology	E	3		3.0		30	70	7,8	
MA4230	Number Theory and Cryptography	E	3		3.0		30	70	7,8	
MA4240	Mathematical Methods in Theoretical Physics	E	3		3.0		30	70	7,8	
Total										**13**

Minor in Mathematics: A minor in mathematics is awarded if a student meets the following minimum requirements:

- MA2014, MA2024, MA2034, MA3014 and MA3024
- For the minor in Statistics (At least one module from MA40xx)
- For the minor in Mathematics (At least one module from MA41xx or MA42xx)

Minor in Entrepreneurship

Code	Module Name	Category	Hours/Week		Credits		Evaluation		Semester	Credits required
			Lecture	Lab/Tute	GPA	NGPA	CA%	WE%		
MN2020	Entrepreneurship Theory	C	3		3.0		50	50	2	3
MN3021	Entrepreneurship Business Basics	C	3		3.0		50	50	4	3
MN3011	Multidisciplinary Design, Innovation and Venture Creation	C	2		2.0		50	50	5	2
MN4011	Business Plan Development	C	2		2.0		40	60	8	2
MN3053	Industrial Management and Marketing	E	3		3.0		30	70	5	2
MN3043	Business Economics and Financial Accounting	E	3		3.0		30	70	5	
MN4023	Engineering Economics	E	2		2.0		30	70	7	
MN4093	Management Skills Development	E	2		2.0		30	70	8	
Total										**12**

Minor in Pattern Recognition

Code	Module Name	Category	Hours/ Week		Credits		Evaluation		Semester	Credits required
			Lecture	Lab/Tute	GPA	NGPA	CA%	WE%		
EN3150	Pattern Recognition	C	2	2	3.0		70	30	5	6
EN3330	Introduction to Engineering Optimization	C	2	2	3.0		70	30	6	
EN4640	Statistical Signal Processing	E	2	2	3.0		60	40	7	6
EN4554	Deep Learning for Vision	E	2	2	3.0		60	40	7	
EN4574	Advanced Pattern Recognition	E	2	2	3.0		60	40	8	
EN4730	Convex Engineering Design	E	2	2	3.0		70	30	8	
EN4470	Probabilistic System Analysis	E	2	2	3.0		60	40	8	
Total										**12**

Faculty Electives

Semester 2								
Code	Module Name	Hours/Week		Credits		Evaluation	
		Lecture	Lab/Tute	GPA	NGPA	CA%	WE%
CS2813	Visual Programming	1	2	2.0	-	40	60
CS2843	Computer Systems	2	2	3.0	-	40	60
EN1055	Introduction to Telecommunications	2		2.0	-	40	60
EN1803	Basic Electronics for Engineering Applications	2	2	3.0	-	40	60
ME1803	Introduction to Manufacturing Processes	2	2	3.0	-	40	60
MN2020	Entrepreneurship Theory	3		3.0	-	50	50

Semester 3							
Code	Module Name	Hours/Week		Credits		Evaluation	
		Lecture	Lab/Tute	GPA	NGPA	CA%	WE%
CE2830	Road Safety and User Behaviour	2	2	3.0	-	50	50
CS2813	Visual Programming	1	2	2.0	-	60	40
ER2631	Elementary Gemmology	3/2	2/2	2.0	-	30	70
ER2210	Subsurface Ventilation	2	0	2.0	-	30	70
EE2804	Applied Electricity	2	2	3.0	-	40	60
EN1803	Basic Electronics for Engineering Applications	2	2	3.0	-	40	60
ME1803	Introduction to Manufacturing Processes	2	2	3.0	-	40	60
ME1823	Fundamentals of Engineering Thermodynamics and Applications	5/2	2/2	3.0	-	30	70
LT2030	Operations Engineering	4/2	4/2	3.0	-	40	60
LT2050	Principles of Supply Chain Engineering	4/2	4/2	3.0	-	40	60
MA2014	Differential Equations	2	-	2.0	-	30	70
MA2024	Calculus	2	-	2.0	-	30	70
MA2034	Linear Algebra	2	-	2.0	-	30	70
MA3014	Applied Statistics	2	-	2.0	-	30	70
MA3024	Numerical Methods	2	-	2.0	-	30	70
EL2410	Introduction to Literary Criticism	3	-	3.0	-	100	-
EL2510	Academic Writing for Engineering Studies	3	-	3.0	-	100	-

Semester 4							
Code	Module Name	Hours/Week		Credits		Evaluation	
		Lecture	Lab/Tute	GPA	NGPA	CA%	WE%
BM2860	Biomedical Engineering and Applications	2	2	3.0	-	40	60
CS2833	Modular Software Development	2	2	3.0	-	50	50
CS2023	Data Structures and Algorithms	2	2	3.0	-	40	60
CS3033	Computer Networks	2	2	3.0	-	40	60
EN2853	Embedded Systems and Applications	2	2	3.0	-	60	40
EN2860	Electronic Instrumentation and Signal Processing	2	2	3.0	-	40	60
ME2851	Fundamentals of Machine Elements Design	2	2	3.0	-	30	70
ME1823	Fundamentals of Engineering Thermodynamics and Applications	5/2	2/2	3.0	-	30	70
LT2110	Transport Demand Modelling and Simulation	4/2	4/2	3.0	-	40	60
MA2034	Linear Algebra	2	-	2.0	-	30	70
MA2054	Graph Theory	2	-	2.0	-	30	70
MA3014	Applied Statistics	2	-	2.0	-	30	70
MA3024	Numerical Methods	2	-	2.0	-	30	70
MN3021	Entrepreneurship Business Basics	3	-	3.0	-	50	50
EL2420	Introduction to Poetry and Drama	3	-	3.0	-	100	
EL2520	Technical Report Writing for Engineering Studies	3	-	3.0	-	100	

Semester 5							
Code	Module Name	Hours/Week		Credits		Evaluation	
		Lecture	Lab/Tute	GPA	NGPA	CA%	WE%
CS3033	Computer Networks	2	2	3.0	-	40	60
CS3413	Advanced Networking	2	2	3.0	-	40	60
ER3420	Petroleum Engineering Upstream Processes	3	0	3.0	-	40	60
EN3021	Digital Systems Design	2	2	3.0	-	50	50
EN3150	Pattern Recognition	2	2	3.0	-	70	30
EN3230	Wireless Networks	2	2	3.0	-	50	50
EN3251	Internet of Things	2	2	3.0	-	100	0
EN3563	Robotics	2	2	3.0	-	50	50
TE3220	Analytics for Manufacturing and Servicing Businesses	5/2	2/2	3.0	-	70	30
MA2024	Calculus	2	-	2.0	-	30	70
MA3014	Applied Statistics	2	-	2.0	-	30	70
MA3024	Numerical Methods	2	-	2.0	-	30	70
MA3030	Operational Research	2	-	2.0	-	30	70
MN3011	Multidisciplinary Design, Innovation and Venture Creation	2	-	2.0	-	50	50
MN3053	Industrial Management and Marketing	3	-	3.0	-	30	70
MN3043	Business Economics and Financial Accounting	3	-	3.0	-	30	70
EL3410	Contemporary South Asian Writing	3	-	3.0	-	100	-
EL3510	Professional Communication for Engineering Contexts	3	-	3.0	-	100	-

Semester 6							
Code	Module Name	Hours/Week		Credits		Evaluation	
		Lecture	Lab/Tute	GPA	NGPA	CA%	WE%
EN3330	Introduction to Engineering Optimization	2	2	3.0		70	30

Semester 7								
Code	Module Name	Hours/Week		Credits		Evaluation	
		Lecture	Lab/Tute	GPA	NGPA	CA%	WE%
BM4152	Biosignal Processing	2	2	3.0		70	30
BM4302	Medical Image Processing	2	2	3.0		70	30
BM4322	Genomic Signal Processing	2	2	3.0		50	50
CE4581	Intelligent Transportation Systems	2	1	3.0		40	60
CE4611	Sustainable design and whole lifecycle	3	0	3.0		100	0
CE4571	Operations Research for Infrastructure Systems	2	1	3.0		40	60
CH4140	Biotechnology	2	2	3.0		40	60
CH4235	Polymer Processing Operations	2	2	3.0		30	70
CH3720	Waste to Energy	2	2	3.0		40	60
CH4440	Petrochemical Process Operations	2	2	3.0		30	70
CH3253	Environmental Bioengineering	2	2	3.0		30	70
CS3121	Introduction to Data Science	2	2	3.0		40	60
CS3203	Software Engineering Project	1	4	3.0		100	
CS3501	Data Science & Engineering Project	1	4	3.0		100	
ER4730	Sustainable Consumption of Earth Resources	2	2	3.0		60	40
EE4715	Nuclear Power and Engineering Applications	2	2	3.0		40	60
EN4470	Probabilistic System Analysis	2	2	3.0		60	40
EN4554	Deep Learning for Vision	2	2	3.0		60	40
EN4640	Statistical Signal Processing	2	2	3.0		60	40
EN4594	Autonomous Systems	2	2	3.0		50	50
MT4281	Surface Engineering and Tribiology	5/2	1	3.0		40	60
MT4810	Continuum Scale Numerical Simulation of Material Systems	5/2	1	3.0		40	60
TE4290	Production Planning & Control	5/2	2/2	3.0		40	60
TE4230	Textile Composites	5/2	2/2	3.0		30	70
LT4020	Project Management and Appraisal	4/2	4/2	3.0		40	60
MA4014	Linear Models and Multivariate Statistics	3		3.0		30	70
MA4090	Mathematical Statistics	3		3.0		30	70
MA4034	Time Series and Stochastic Process	3		3.0		30	70
MA4000	Experimental Design and Quality Control	3		3.0		30	70

Semester 7 (continued)							
Code	**Module Name**	**Hours/Week**		**Credits**		**Evaluation**	
		Lecture	**Lab/Tute**	**GPA**	**NGPA**	**CA%**	**WE%**
MA4110	Finite Element Analysis	3		3.0		30	70
MA4120	Advanced Differential Equations	3		3.0		30	70
MA4130	Optimization	3		3.0		30	70
MA4144	Neural Networks and Fuzzy Logic	3		3.0		30	70
MA4150	Financial Mathematics	3		3.0		30	70
MA4160	Advanced Operational Research	3		3.0		30	70
MA4210	Mathematical Analysis and Special Functions	3		3.0		30	70
MA4220	Topics in Algebra and Topology	3		3.0		30	70
MA4230	Number Theory and Cryptography	3		3.0		30	70
MA4240	Mathematical Methods in Theoretical Physics	3		3.0		30	70
MN4023	Engineering Economics	2		2.0		30	70
EL4410	Literature and Translation	3		3.0		100	
EL4510	Research Communication for Engineering Studies	3		3.0		100	

Semester 8							
Code	Module Name	Hours/Week		Credits		Evaluation	
		Lecture	Lab/ Tute	GPA	NGPA	CA%	WE%
CE4621	Engineering Response to Climate Change	3	0	3.0		100	
CS3121	Introduction to Data Science	2	2	3.0		40	60
CS3203	Software Engineering Project	1	4	3.0		100	
CS3501	Data Science & Engineering Project	1	4	3.0		100	
ER4740	Remote Sensing and GIS for Engineers	2	2	3.0		30	70
EE3064	Energy Systems	2	2	3.0		40	60
EE4380	Reliability Evaluation of Engineering Systems	2	2	3.0		40	60
EE4410	Electrical Services for Buildings	2	2	3.0		40	60
EN4574	Advanced Pattern Recognition	2	2	3.0		60	40
EN4650	Computer Systems Architecture	2	2	3.0		70	30
EN4730	Convex Engineering Design	2	2	3.0		70	30
MT4420	Energy Materials	5/2	1	3.0		40	60
MT4774	Paint Technology	5/2	1	3.0		40	60
ME2860	Automotive Technology	5/2	2/2	3.0		40	60
TE4330	Smart and Functional Textiles	5/2	2/2	3.0		40	60
MA4014	Linear Models and Multivariate Statistics	3		3.0		30	70
MA4090	Mathematical Statistics	3		3.0		30	70
MA4034	Time Series and Stochastic Process	3		3.0		30	70
MA4000	Experimental Design and Quality Control	3		3.0		30	70
MA4110	Finite Element Analysis	3		3.0		30	70
MA4120	Advanced Differential Equations	3		3.0		30	70
MA4130	Optimization	3		3.0		30	70
MA4144	Neural Networks and Fuzzy Logic	3		3.0		30	70
MA4150	Financial Mathematics	3		3.0		30	70
MA4160	Advanced Operational Research	3		3.0		30	70
MA4210	Mathematical Analysis and Special Functions	3		3.0		30	70
MA4220	Topics in Algebra and Topology	3		3.0		30	70
MA4230	Number Theory and Cryptography	3		3.0		30	70
MA4240	Mathematical Methods in Theoretical Physics	3		3.0		30	70
MN4011	Business Plan Development	2		2.0		40	60
MN4093	Management Skills Development	2		2.0		30	70
EL4420	Science Fiction: Cyborgs and Dystopia	3		3.0		100	
EL4520	Journalism and Journalistic Writing	3		3.0		100	

Humanities Subjects

Semester 2											
Code	Module Name	Category	Hours/ Week		Credits		Norm		Evaluation		
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA%	WE%
HM2480	History and Development of Engineering	E	2		2.0				100	
HM2450	Introduction to Psychology	E	2		2.0				100	
HM2510	Sri Lankan Built Heritage	E	2		2.0				100	
HM2610	Nutrition and Health	E	2		2.0				100	
HM2620	Food and Nutrition	E	2		2.0				100	
HM2630	Photography	E	2		2.0				100	
HM2640	Photography as an Art	E		4	2.0				100	
HM2710	Astronomy and Cosmology	E	2		2.0				100	
HM2430	Human Rights	E	2		2.0				100	
HM2410	Responsible Citizenship	E	2		2.0				100	
HM2330	Yoga Practice	E		4	2.0				100	
HM2010	Sinhala as a Second Language	E	2		2.0				100	
HM2020	Tamil as a Second Language	E	2		2.0				100	
HM2110	Effective Communication	E	2		2.0				100	
HM2210	Creative Writing	E	2		2.0				100	
Total					**30.0**	**0.0**	**0.0**	**0.0**		

Semester 4										
Code	Module Name	Category	Hours/ Week		Credits		Norm		Evaluation	
			Lecture	Lab/Tute	GPA	NGPA	GPA	NGPA	CA%	WE%
HM2310	Meditation	E	2		2.0				100	
HM2610	Nutrition and Health	E	2		2.0				100	
HM2460	Public Administration	E	2		2.0				100	
HM2670	Video Production	E		4	2.0				100	
HM2520	Intangible Heritage of Sri Lanka	E	2		2.0				100	
HM2350	Western Classical Music	E		4	2.0				100	
HM2470	Life skills for Engineers	E		4	2.0				100	
HM2660	Digital Photography	E		1	2.0				100	
HM2010	Sinhala as a Second Language	E	2		2.0				100	
HM2030	Japanese as a Foreign Language	E	2		2.0				100	
HM2040	Chinese as a Foreign Language	E	2		2.0				100	
Total					**30.0**	**0.0**	**0.0**	**0.0**		

Modules

Semester I

Semester	Code	Module Title	Credits	C/E/O	GPA / NGPA
1	CE1023	Fluid Mechanics	2.0	C	GPA
Hours/Week		**Prerequisites / Corequisites**	**Evaluation %**		
Lecture	**Lab/Tutes**		**CA**	**WE**	
2	2/4	None	20	80	

Learning Outcomes

After completing this module, students should be able to,

- define the properties of fluids and describe the significance of such properties in applications in engineering practice,
- determine hydrostatic forces on submerged surfaces/ bodies and assess the conditions for equilibrium and stability such surfaces/bodies in applications in engineering practice, and
- apply the concepts of conservation of mass, energy and momentum of fluids and determine the velocities, pressures, flow rates, forces, etc., in applications in engineering practice.

Syllabus Outline

1. Introduction: applications in fluid mechanics
2. Characteristics/ Properties of Fluids
3. Fluid Statics
4. Fluids in Motion
5. Introduction to Hydraulic machinery

Semester	Code	Module Title	Credits	C/E/O	GPA / NGPA
1	CS1033	Programming Fundamentals	3.0	C	GPA

Hours/Week		Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes		CA	WE
2	2	None	20	80

Learning Outcomes

After completing this module, students should be able to

- Device algorithms to solve simple computational problems
- Develop programs from algorithms using a high-level programming language (e.g., Python)
- Develop programs for simple control applications using embedded hardware platforms

Syllabus Outline

- Introduction to Computing
- Python: Introduction, Operators, Expressions
- Python: Selection Control Structures
- Python: Loop Control Structures SP
- Python: Lists
- Python: Functions
- Data Representation
- Problem Solving I
- Problem Solving II
- Problem Solving III
- Computer System & Hardware I
- Computer System & Hardware II

Semester	Code	Module Title	Credits	C/E/O	GPA / NGPA
1	EE1040	Electrical Fundamentals	2.0	C	GPA

Hours/Week		Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes		CA	WE
2	2/4	None	20	80

Learning Outcomes

After completing this module, the student should be able to;

- Describe the practical aspects of basic circuit elements.
- Analyze ac circuits using series/parallel simplifications, voltage/current division rules.
- Solve three-phase balanced circuits in terms of line quantities and power.
- Draw up a complete wiring circuit f a hushed and appreciate the importance f different
- protecting and safety devices

Syllabus Outline

1. Overview of Electrical Engineering
2. Basic Circuit Elements
   Physical characteristics of linear circuit elements (resistors, inductors and capacitors), voltage-current relationships, voltage sources, solutions of resistive circuits using Kirchoff's laws.
3. AC Theory
   Sinusoidal waveform, waveform parameters, phasor representation, complex representation, impedance, admittance, complex power and energy, power factor, series/parallel simplifications, voltage/current division rules, AC circuit calculations.
4. Three Phase Balanced Circuits
   Definition of balanced three phase systems, circuit diagrams, delta-star connection and transformation, per-phase equivalent circuit, power factor correction.
5. Circuit Protection and Basic Electrical Safety
   Basic components of a domestic electrical system, overcurrent/short circuit protection, earth leakage protection, devices, case studies

Semester	Code	Module Title	Credits	C/E/O	GPA / NGPA
1	MA1014	Mathematics	3.0	C	GPA

Hours/Week		Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes		CA	WE
5/2	1	None	20	80

Learning Outcomes

After the successful completion of this course, students should be able to

- Identify basic operations and functions of complex variables, explore 3D geometry using vectors and solve basic eigenvalue problems for matrices.
- Use real functions of one real variable up to power series.
- Solve Differential Equations up to second order linear with non-constant coefficients

Syllabus Outline

Algebra

- Complex Numbers: Euler's Identity, complex valued functions and branches.
- Vectors: vector algebra, vector product, scalar product, scalar triple product, vector triple product, equations of line and plane, vector norms
- Matrices: transpose, adjoint, determinant, inverse and trace of a matrix, system of equations,
- Cramer's rule, Gaussian elimination, echelon forms, rank, eigen values and eigen vectors,
- diagonalization, matrix norms.

Real Analysis

- Sets and Inequalities: Introduction to quantifiers and sets, real number system, inequalities,
- supremum and infimum, completeness axioms.
- Functions, Limits and Differentiability: relations, functions and their inverses, limit of a function, continuity, differentiability
- Basic Theorems: Intermediate value theorem, extremum value theorem, Rolle's theorem, mean value theorem, L' Hopital's rule.
- Sequences and Series: Convergence of sequences and series, monotone convergence theorem.

Power series, Taylor's series.

Integration and ODE

- Riemann integration: integral as an area, First and second fundamental theorems of calculus,
- Leibniz rule, Integrability of a continuous function, Integration by parts, mean value theorem for integrals, Improper integrals: tests of convergence, gamma function.
- Ordinary differential equations: classification of ODEs (Linear and non-linear), First order
- ordinary differential equations: variable separable, homogeneous, linear, Bernoulli Second order linear differential equations: equations with constant coefficients, Wronskian method

Semester	Code	Module Title	Credits	C/E/O	GPA / NGPA
1	ME1033	Mechanics	2.0	C	GPA

Hours/Week		Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes		CA	WE
2	2/4	None	20	80

Learning Outcomes

Upon completing this course, the students should be able to:

- Calculate sectional properties of plane areas,
- Calculate internal forces in beams,
- Identify statically determinate / indeterminate trusses, their stability and determine forces in truss members.
- After completing this part (Dynamics) of the module, the students should be able to:
- Analyse the geometry of motion of particles, rigid bodies and 2D linkages,
- Determine forces and energy associated in particles and rigid bodies in motion,
- Analyse natural vibrations of damped, single degree of freedom systems.

Syllabus Outline

Statics

- Properties of plane areas
- Internal forces (BMD & SFD)
- Principle of superposition
- Determination of forces in assemblies of rigid bodies

Dynamics

- Fundamentals of Dynamics
- Kinematics of particles (rectilinear and curvilinear motion, relative motion, general motion in 2D) and rigid bodies (relative motion between two points in a rigid body, velocities in 2D link
- mechanisms, instantaneous centre of rotation method, introduction to acceleration)
- Kinetics of particles and rigid bodies (force, torque, work, energy and power, linear momentum, angular momentum)
- Mechanical Vibrations
- Free vibrations (undamped and damped) of single degree of freedom systems.

Semester	Code	Module Title	Credits	C/E/O	GPA / NGPA
1	MT1023	Properties of Materials	2.0	C	GPA

Hours/Week		Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes		CA	WE
2	2/4	None	20	80

Learning Outcomes

At the completion of this module, students should be able to;

- Recognize the structure of metals, polymers and ceramics
- Identify the relationships between the structure of materials, their properties and applications
- Assess the properties of engineering materials

Syllabus Outline

- Introduction to engineering materials
- Structure of atoms, atomic theories, atomic bonding in materials
- Crystal structures and defects
- Introduction to nanomaterials
- Mechanical properties of materials
- Electrical properties of materials
- Degradation of Materials
- Functional Materials and their applications
- Basic materials selection

Semester	Code	Module Title	Credits	C/E/O	GPA / NGPA
1,2	EL1030	Language Skills Enhancement	2.0	C	GPA

Hours/Week		Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes		CA	WE
	2	None	100	0

Learning Outcomes

At the completion of this module students should be able to:

- Demonstrate having achieved the competencies for listening, speaking, reading and writing (UTEL bands 6, 7 and 8 respectively)

Syllabus Outline

- Listening comprehension: spoken texts and dialogues
- Speaking on given topics.
- Asking questions and responding to questions.
- Reading comprehension
- Summarising and synthesising
- Describing objects, mechanisms and processes
- Discussion/ writing activities
- Describing data and graphical information
- Functional grammar

Semester II

Semester	Code	Module Title	C/E/O	GPA / NGPA
2	CH1051	Engineering Thermodynamics	C	GPA

Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	None	40	60

Learning Outcomes

On successful completion of this module, students are able to:

- LO1: *Understand* the basic concepts in thermodynamics.
- LO2: *Recognize* the applicability of Laws of thermodynamics in process industry.
- LO3: *Analyse* flow processes and nonflow processes.
- LO4: *Explain* the P-v-T behaviour of real and ideal gases.
- LO5: *Describe* different forms of energy and the limitations of the world's energy resources.
- LO6: *Apply* Laws of thermodynamics for cyclic processes and liquefaction processes.

Syllabus Outline

Basic concepts in Thermodynamics

Scope and limitations of thermodynamics, Systems and processes, State and properties, Phase rule, Zeroth Law, Heat reservoirs and Heat engines, Different flow patterns

First Law of Thermodynamics

Moving boundary, General energy balance relation, Specific heats, Relations for the internal energy and enthalpy of ideal gases; General conservation of mass relation for control volumes, Flow work and the energy of fluid streams

P-v-T behaviour

Various property diagrams and P-v-T surfaces of pure substances, Property tables, Ideal-gas equation of state, Compressibility factor, Deviation of real gases from ideal-gas behaviour: van der Waals, Beattie-Bridgeman, and Benedict-Webb-Rubin equations

Second laws of Thermodynamics

Various statements of the second law, Perpetual motion machines and the thermodynamic temperature scale, Clausius inequality and the basis for the definition of entropy, Increase of entropy principle, Isentropic processes, Steady flow work

Applications of the Laws of Thermodynamics

Energy: Concept of energy, Reversible work, Energy destruction, Second-law efficiency, Exergy balance

Flow processes: Continuity and energy equations, Flow in pipes, nozzles, ejectors, and compressors

Refrigeration: Refrigerators and heat pumps, Reversed Carnot cycle, Vapor-compression refrigeration cycle, Introduction to gas refrigeration cycles

Liquefaction processes: Vaporization of liquid, Free expansion, Isentropic expansion

Steam power plants: Carnot vapor cycle, Rankine cycle and applications

Internal combustion engine: Carnot cycle, Air standard assumptions, Reciprocating engines, Auto cycle, Diesel cycle

Gas-turbine power plants: Brayton Cycle

Semester	Code	Module Title		C/E/O	GPA / NGPA
2	CH1044	Fluid Dynamics		C	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
3	2	4.0	CE1023	40	60

Learning Outcomes

After completing this module, the students should be able to,

- LO1: *Understand* the general concepts of momentum transport.
- LO2: *Recognize* different flow patterns and analyze their applications.
- LO3: *Use* integral analysis and differential analysis techniques to analyze fluid flow.
- LO4: *Apply* dimensional analysis and conservation laws in solving problems in fluid flow.
- LO5: *Design* basic fluid flow systems in process industry.

Syllabus Outline

General concepts of momentum transport

Viscosity, Mechanisms of momentum transport: molecular momentum transport and convective momentum transport, Analogy of mass, momentum and energy transport, Conservation Laws: continuity equation, momentum equation and energy Equation.

Different flow patterns

Laminar and Turbulent behaviour of fluid flow, Flow of a falling film, Flow through an annulus, Flow between parallel plates, Rotational viscometers, Power transmission between parallel discs, Creeping flow, Fully developed pipe flow, Pressure drop and head loss, Effect of gravity on velocity and flow rate, Newtonian and Non-Newtonian flow in pipes, Roughness of the walls of the pipe, Boundary layer and the viscous sub layer, Eddy viscosity, Moody diagram, Reynolds stress, Prandlt's mixing length theory, Velocity distribution in turbulent flow.

Differential analysis of fluid flow

Differential equations of fluid motion: continuity equation, Euler's Equation and Navier Stokes Equation, Stream function, Boundary layer approximation, Boundary layer thickness, Momentum integral equation, Laminar and turbulent boundary layers, Boundary layers with pressure gradients, Friction and pressure drag.

Dimensional analysis and application of conservation laws

Dimensions, units, Dimensional homogeneity, Dimensional analysis and similarity, Buckingham pi theorem, Pump scaling laws, Pump types, Fundamental parameters in analysing pumps, Pump performance curves and Matching a pump to a piping system, Pump cavitation and Net positive suction head, Minor losses, Series and parallel pipes, Piping systems with pumps and turbines, Flow rate and velocity measurements, Mixing and agitation.

Compressible fluid flow

Compressibility, Mach number, Stagnation properties, One dimensional isentropic flow, Isentropic flow through nozzles, Normal shock waves, Duct flow with heat transfer and negligible friction, Adiabatic duct flow with friction.

Semester	Code	Module Title		C/E/O	GPA / NGPA
2	CH1061	Chemical and Bioprocess Engineering Principles		C	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
3	2	4.0	None	40	60

Learning Outcomes

After completing this module, the students should be able to,

- LO1: *Understand* the evolution of chemical and bioengineering
- LO2: *Select* unit operations necessary for a given process
- LO3: *Identify* resources required for a process based on internal and external constraints
- LO4: *Perform* material balance and energy balance calculations for a given system
- LO5: *Estimate* resource requirements and process parameters using material and energy balance
- LO6: *Explain* the importance of the steps associated with the process scaling up applying to the chemical and process industry
- LO7: *Develop* a process flow sheet

Syllabus Outline

Introduction to Chemical Engineering

Introduction to Bioprocess engineering

Natural resources

Sources of materials; materials from geosphere, hydrosphere atmosphere and biosphere; Sources of energy- renewable and non-renewable

Process Development

Concept of process development, design constraints, steps involved in process design.

Unit Operations

Definitions and applications of different unit operations and processes.

Flow sheeting

types of process plant design diagrams, instrument and equipment identification, computer aided flow sheeting

Material Balance

Balances for non-reacting systems and reacting systems with single and multiple reactions.

Energy Balance

Balances for non-reacting systems and reacting systems with single and multiple reactions.

Transport phenomena

Transport of mass, heat, and momentum

Utilities and instrumentation

Steam production and distribution, types of boilers, cooling water and tower, air compressors, positive displacement and dynamic pumps, types of valves, pipes, and piping

Semester	Code	Module Title		C/E/O	GPA / NGPA
2	CH1071	Chemistry and Green Chemistry for Process Engineers		C	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	None	40	60

Learning Outcomes

After completing this module, the students should be able to;

- LO1: *Acquire* the knowledge on intermolecular interactions and properties of matter and solutions, and use it to understand various chemical engineering processes
- LO2: *Discuss* the phase equilibria, chemical equilibria and acid-base equilibria and apply the knowledge in industrial applications
- LO3: *Apply* principles of electrochemistry to evaluate the interaction between electrical energy and charged chemical species
- LO4: *Distinguish* different organic reaction mechanisms and apply natural product chemistry in related industrial applications
- LO5: *Select* the most suitable polymerization mechanism and process and use them in designing the polymer manufacturing process
- LO6: *Apply* analytical chemistry knowledge in quantitative and qualitative analysis of chemical compounds and evaluate chemical changes
- LO7: *Acquire* the basic knowledge in green chemistry and practice it in good manufacturing processes

Syllabus Outline

Properties of Matter

Intermolecular and intramolecular interactions, Effect of molecular interactions on properties of solids, Liquids and gases, Properties of gases, Gas laws

Phase Equilibria

Definitions of phase, Component and degrees of freedom, Phase rule and its derivations, Definition of phase diagram, Phase equilibria for one component system, Liquid vapor equilibrium for two component systems, Three component systems

Properties of Solutions

Solubility and dissociation process, Saturated solutions and solubility, Factors affecting solubility, Solubility product constant, Colligative properties, Mixtures and Colloids

Chemical Equilibria

Equilibrium constants and their quantitative dependence on temperature, pressure and concentration, Relations of various equilibrium constants, Relationship between chemical kinetics and chemical equilibrium, Factors affecting chemical equilibrium

Acid-Base Equilibria

Strengths of acids and bases (elementary idea), Ionization of weak acids and weak bases in aqueous solution, Ionization constants, Ionic product of water

Electrochemistry

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ions based on half-cell potentials, Chemical cells, reversible and irreversible cells with examples, Electromotive force of a cell and its measurement, Nernst equation; Standard electrode (reduction) potential

Applied Organic Chemistry and Reaction Mechanisms

Introduction to types of organic reactions and their mechanism: Addition, Elimination, Substitution and Rearrangement reactions, The use of organic chemistry and reaction mechanisms in industrial applications

Polymerization Reactions

Free-radical polymerization, Cationic polymerization, Anionic polymerization, Condensation polymerization, Ring-opening polymerization, Coordination polymerization

Polymerization Processes

Bulk polymerization, Solution polymerization, Suspension polymerization and Emulsion polymerization

Analytical Chemistry:

Quantitative and qualitative analysis, Analytical separations, and Chromatographic techniques: Principles and efficiency of the technique, GC, HPLC, Introduction to spectrometric methods: IR spectroscopy, UV Visible spectroscopy, Atomic absorption spectroscopy, NMR spectroscopy, Mass spectrometry

Natural Products and Industrial Applications

Classification of natural products based on the chemical structure, manufacturing process and their applications

Computational Chemistry

Molecular mechanics and force fields, Molecular docking, and simulations

Introduction to Green Chemistry

Introduction to green chemistry, Driving factors of green chemistry, 25 Years of progress, The future of green chemistry, Basic principles of green chemistry

Semester III

Semester	Code	Module Title		C/E/O	GPA / NGPA
3	CH2631	Chemical Thermodynamics		C	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	CH1051	40	60

Learning Outcomes

After completing this module, students should be able to,

- LO1: *Understand* the chemical thermodynamic processes and find the feasibility of such processes.
- LO2: *Apply* the laws of thermodynamics to solve the problems related to chemical changes.
- LO3: *Determine* the heat exchange in chemical reactions.
- LO4: *Analyze* the thermodynamic properties of pure fluids and solutions.
- LO5: *Derive* the relationships of thermodynamic parameters for given applications.
- LO6: *Apply* the thermodynamic concepts to understand and evaluate the phase equilibria and chemical reaction equilibria.

Syllabus Outline

Basic concepts in chemical thermodynamics

Thermodynamic processes involve in chemical changes: phase transitions, chemical reactions, dissolution, Basic definitions of thermodynamic properties based on chemical processes.

Determination of enthalpy changes in chemical reactions: exothermic reactions, endothermic reactions, reversible reactions, Heat changes in dissolution, Phase transitions, Effect of temperature on heat capacity.

Interpretation of thermodynamic laws for chemical processes: irreversible processes, reversible processes, thermal equilibrium, mechanical equilibrium, and material equilibrium.

Thermodynamic properties of pure fluids

Classification of thermodynamic properties.

Gibbs free energy and Helmholtz free energy for chemical processes.

Relationships among thermodynamic properties: Gibbs equations and Maxwell relations, Clausius-Clapeyron Equation.

Fugacity, effect of temperature and pressure on fugacity, fugacity of solids and liquids.

Activity, effect of pressure and temperature on Activity.

Thermodynamic properties of solutions

Partial molar properties, Chemical potential, Fugacity in solutions, Henry' Law and dilute solutions, Activity in solutions and Activity coefficients, Gibbs-Duhem Equations, Property changes of mixing, Heat effects of mixing.

Phase equilibria

Phase equilibria in single-component and multi-component systems, Phase rule for non-reacting systems, Vapour liquid equilibria, Phase diagram for binary solutions, Non-ideal solutions, Vapour-liquid equilibria, Liquid-liquid equilibrium diagrams.

Chemical Reaction equilibrium

Equilibrium constant and standard free energy change, Effect of temperature and pressure on Equilibrium constant, Other factors affecting equilibrium conversions, Liquid-phase reactions, Heterogeneous reaction equilibria.

Semester	Code	Module Title		C/E/O	GPA / NGPA
3	CH2015	Heat and Mass Transfer		C	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
3	2	4.0	CH1051, CH1044	40	60

Learning Outcomes

After completing this module, students should be able to,

- LO1: *Recognize* the heat and mass transfer related equipment in the process industry.
- LO2: *Understand* basic principles of heat and mass transfer.
- LO3: *Analyze* heat and mass transfer problems using conservation equations.
- LO4: *Calculate* heat and mass transfer coefficients.
- LO5: *Understand* the concepts related to mass exchanger design.
- LO6: *Design* a heat exchanger for a given duty.

Syllabus Outline

Introduction

Momentum, heat, and mass transfer analogies, three modes of heat transfer mechanisms.

Heat Conduction

Derivation of general three-dimensional conduction equation, steady state one dimensional conduction equations for different geometries, thermal resistance concept & its importance, critical thickness of insulation, heat transfer in extended surfaces, one-dimension unsteady state heat conduction, Lumped system analysis, use of transient temperature charts (Heisler's charts).

Heat Convection

Concepts boundary layers, concepts of heat transfer coefficients, application of dimensional analysis for free convection and force convection, physical significance of dimensionless numbers related to heat convection, use of correlations of free convection and force convection.

Heat Transfer with phase changes

Types of condensation, Nusselt's theory for laminar condensation on a vertical flat surface, use of correlations for condensation; regimes of pool boiling, pool boiling correlations.

Thermal Radiation

Definitions of various terms and laws used in radiation heat transfer, radiation heat exchange between two parallel infinite black surfaces and two parallel infinite Gray surfaces, effect of radiation shield, radiation heat exchange between two finite surfaces, electrical analogy for Gray body heat exchange, gaseous radiation.

Design of Heat Exchangers

Classification of heat exchangers, overall heat transfer coefficient, fouling, and fouling factor, LMTD, Effectiveness-NTU methods of analysis of heat exchangers.

Molecular mass transfer

Introduction to mass transfer, definitions of various terms used in mass transfer, Fick's Law, differential equation of mass transfer, state and unsteady state molecular diffusion, diffusion through a stagnant gas film, equimolecular counter diffusion, diffusion in liquids, diffusion in solids.

Convective Mass Transfer

Significant parameters in convective mass transfer**,** convective mass transfer coefficients, application of dimensional analysis to mass transfer, physical significance of dimensionless numbers related to mass transfer, convective mass transfer correlations, Mass transfer between phases, overall mass transfer coefficient.

Design concepts of Mass Exchangers

Principles involving design of mass exchangers, height of packing, number of transfer units, height of transfer units, mass exchanger design procedure, Applications of mass transfer principles in process industry.

Semester	Code	Module Title		C/E/O	GPA / NGPA
3	CH2160	Bioprocess Engineering and Practices		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	None	40	60

Learning Outcomes

After completing this module, the student should be able to,

- LO1: *Discuss* the integration of chemical engineering and biotechnology for the synthesis of bioproducts.
- LO2: *Recognize* the principles and applications of bioprocess engineering.
- LO3: *Identify* and analyse parameters critical for process control in biotechnological processes.
- LO4: *Describe* upstream and downstream aspects of industrial bioprocesses.
- LO5: *Evaluate* the important aspects in bioprocess engineering for commercialization of bioproducts and maintaining product safety.
- LO6: *Demonstrate* knowledge on the applicability of bioprocess engineering for developing a sustainable bioeconomy.

Syllabus Outline

Bridge between biotechnology and chemical engineering
Integration of biotechnology and chemical engineering to manufacture products, bioresources, chemical engineering approaches for value addition to bioresources, bioprocesses to enhance the sustainability of manufacturing processes.

Adopting natural phenomena as applications in bioprocess engineering
Process parameters in biological processes, enzymatic reactions for sustainable production, biomimetics: adapting processes, substances, devices, or systems that resemble nature, applications from nature for the food industry

Biomolecular composition in valorization of bioresources
Describe biomolecular composition of various bioresources, effect of biochemical composition on potential applications and downstream processes, effect of biochemical composition on product quality, understanding computational methods in valorization.

Bioprocesses
Advantages of bioprocesses over conventional processes, introduction to unit operations and downstream processing in biochemical engineering, brief introduction to bioreactor operation and bioprocess parameters, scale up considerations in bioprocess engineering.

Cell cultivation for bioprocesses
Microorganisms for bioprocesses, microbial growth requirements for different applications, cell growth measurement in bioprocesses, recent advances in cell cultivation, introduction to microbial growth kinetics

Engineering practices in bioprocesses
Sterile practices, techniques for microbiologically safe production processes, food-water-energy nexus

Biohazards and biosafety in bioprocesses
Pathogens and contaminants, discussion with reference to exposures and incidents, biohazards, and pandemics

Enzymes in process industry
Advantages of enzyme catalysed reactions over chemical catalysts, enzyme synthesis, parameters critical for enzymatic activity

<table>
<tr><th>Semester</th><th>Code</th><th colspan="2">Module Title</th><th>C/E/O</th><th>GPA / NGPA</th></tr>
<tr><td>3</td><td>CH2170</td><td colspan="2">Laboratory Practices I</td><td>C</td><td>GPA</td></tr>
<tr><th colspan="2">Hours/Week (spread over two semesters</th><th rowspan="2">Credits</th><th rowspan="2">Prerequisites / Corequisites</th><th colspan="2">Evaluation %</th></tr>
<tr><th>Lecture</th><th>Lab/Tutes</th><th>CA</th><th>WE</th></tr>
<tr><td>0</td><td>6</td><td>3.0</td><td>Prerequisites: CH1044, CH1071
Corequisites: CH2160, CH2015</td><td>100</td><td>0</td></tr>
</table>

Learning Outcomes

After completing this module, the student should be able to**:**

- LO1: *Understand* the basics of engineering drawing and Draw the orthographic projections of a given mechanical part or assembly.
- LO2: *Recognize* suitable software tools for chemical and process engineering applications.
- LO3: *Apply* software tools to analyse fluid dynamics and heat & mass transfer applications.
- LO4: *Understand* the basic concepts and techniques relevant to fundamentals in chemical and process engineering.
- LO5: *Apply* appropriate methods to plot, analyse and present experimental results, and verify principles when applicable.

Syllabus Outline

Laboratory Practices I module covers the practical aspects of fundamentals in Chemical and Process Engineering (CH1044, CH1071, CH2160, and CH2015) and provide introduction to engineering drawing and computer aided learning.

Engineering Drawing and Computer Aided Learning

Engineering drawing (Part drawing, assembly drawing -manual); Introduction to engineering drawing and drawing software packages (AutoCAD®/ SOLIDWORKS®).

Introduction to MATLAB– matrix, loops and arrays, development of script and function files.

Computational methods for heat and mass transfer: introduction to computational fluid dynamics and development of heat and mass transfer models (1-D model solving by MATLAB®).

Dynamic behaviour of systems and stability-Linear State Space Models (development of lump model based on CH1044 and CH2015, pressure in distributed gas pipe-model development and simulation by Python)

Laboratory Experiments (8 Sessions)

(1) Centrifugal pump demonstration; Flow meter demonstration. (2) Determination of hardness of water.

(3) Synthesis of ethyl butanoate. (4) Identification of biomolecules. (5) Isolation and identification of microorganisms

(6) Determination of outside heat transfer coefficient of circular pipes. (7) Study of analogy between fluid friction and heat transfer/ Demonstration on gas and liquid diffusion. (8) Determination of viscosity index of petroleum oil and proximate analysis of coal.

Open-ended lab

Problem-Based Learning method is used in this experimental base project, where students are given the freedom to develop their own laboratory work, instead of merely following the already set guidelines.

Semester IV

Semester	Code	Module Title			C/E/O	GPA / NGPA
4	CH2151	Particulate Systems			C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**		**Evaluation %**	
Lecture	**Lab/Tutes**				**CA**	**WE**
3	2	4.0	CH1044, CH1061		40	60

Learning Outcomes

After completing this module, students should be able to:

- LO1: *Derive* governing equations for the motion of particle/s in a fluid
- LO2: *Calculate* and analyze size, shape, size distribution of a particle system
- LO3: *Analyze* the flow characteristics of fluid flow in packed beds and fluidized beds and unit design
- LO4: *Select* suitable operation and equipment for the given operation in handling particulate matter
- LO5: *Design* process equipment for handling, generation, and separation of particulate matter
- LO6: *Describe* fundamentals of nanoparticles and investigate its applications in chemical engineering practice

Syllabus Outline

Particle Dynamics
The Motion of a Single Particle in an Infinite Extent of Fluid, Equation of motion, Reynold Number, Suspension Settling, Classification of Particles based on terminal settling velocities
Particle Statistics
Mean diameters, particle shape, Non spherical particles, equivalent diameters, particle size distributions, Particle size Analysis
Size reduction, enlargement and Blending of solids
Powder technology
Powder statics and the design of hoppers
Analysis of fire and hazards of powders in industry
Flow of fluids through porous solid beds
Ergun's equation for, Pressure Drop Across the Bed. Carmen and Kozeny equation, Burke, and Plummer equation. Two Phase Flow Through Porous Solid Beds, Loading and Flooding conditions. Diameter calculation for gas-liquid contact equipment
Fluidization
Introduction to Fluidization, Minimum Fluidization condition, Pressure drop vs. Fluid velocity relation, Entrainment in fluidized beds, Heat Transfer in fluidized beds, fluidized bed design, Scale up, Spouted Beds, Hydraulic and Pneumatic Conveying
Solid Liquid Separation
Classification of solid liquid separation equipment, Sedimentation, Design of Thickeners
Filtration -Modes of filtration, Equations for filtration rate, Filtration equipment, Filter area calculation. Classification of filters. Membrane separation processes
Centrifugation- The basic principle of centrifugation, Classification of Centrifuges, Separation of two immiscible liquids in a centrifuge. Solid-liquid separation in a centrifuge, Maximum stress on the walls of the centrifuge

Dust and Mist Separation from Gas Streams
Gas cleaning techniques, gravity settling, momentum separators, scrubbers, filters, electrostatic precipitators, magnetic precipitators cyclones, reverse flow cyclone design
Nanotechnology
Introduction to nanotechnology, discuss nanoparticles as a major branch of nanotechnology, compare different options in synthesis, separation, characterization, and applications of nanoparticles in chemical engineering domain.
Crystallization
Principles of crystallization, Nucleation, Kinetics of crystallization, Heat and mass balance, yield, equipment, and design calculations

Semester	Code	Module Title	C/E/O	GPA / NGPA
4	CH2180	Separation Processes	C	GPA

Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
3	4	5.0	CH1061	40	60

Learning Outcomes

The students will learn the design and operation of standard separation processes used in the chemical industries; Distillation, Absorption/Stripping, Extraction, Adsorption, Drying, Humidification and Evaporation.

At the end of the course the students are expected to;

- LO1: *Analyse* the desired separation and select the suitable Unit Operation
- LO2: *Describe* principles and equilibrium concepts in separation processes
- LO3: *Apply* material and energy balances for the separation processes
- LO4: *Describe* the effects of various operating variables on the separation output
- LO5: *Design* separation process equipment based on graphical or algebraic analysis

Syllabus Outline

Introduction
Introduction to the role of separation; Common separation processes; Mechanism of separation.

Distillation
Vapor-liquid Equilibrium for binary and multicomponent systems, Differential Distillation, Equilibrium Flash Distillation, Continuous Distillation with Reflux, McCabe-Thiele Analysis, Multistage Batch Distillation, Multiple feeds, side streams, FUG method, Lewis and Matheson method, Complex distillation methods – azeotropic, extractive and two pressure distillation, Design of tray distillation columns and column internals.

Gas Absorption & Stripping
Gas-liquid equilibrium,
Determination of Number of Ideal Stages by graphical method, Theoretical Method (Kremser Equation)
Determine the height of continuous contact separator HTU NTU method, Packed column design.

Solvent Extraction
Introduction to Liquid-Liquid Extraction, Phase equilibrium for partially miscible systems, Triangular diagram, Modes of Extraction, Solvent Selection, Phase equilibrium for Immiscible systems Solid-Liquid Extraction, Super Critical Extraction, Determination of number of equilibrium stages for extraction, Extraction column design.

Adsorption and ion exchange
Types of adsorbents, Adsorption equilibrium, modes of adsorption, single stage, cross flow, counter-current and fixed adsorption unit design calculations, Breakthrough curves, adsorption regeneration, ion exchange resins, equilibrium, kinetics, and equipment.

Evaporation
Introduction to evaporation, Boiling Point Rise (BPR)and Dühring charts, Single stage evaporator calculations, Multiple stage evaporator calculations, Discuss on various modes of evaporators and their industrial applications, Vapor re-compression in evaporators.

Humidification Operations
Basic principles on Humidification Operations, Sample problems to understand the basic terms in humidification. Introduction to psychometric chart and its applicability for humidification and dehumidification operations, Introduction to cooling tower working principle, Preliminary design calculations for cooling towers and spray chambers based on mass and energy balance.

Drying
Introduction to basic principles and Drying curves, Identify the drying process on a psychrometric chart for a given scenario, Different modes of Drying, Calculations to determine the drying parameters under different modes of drying, Dryer design.

<table>
<tr><th colspan="2">Semester</th><th>Code</th><th colspan="2">Module Title</th><th>C/E/O</th><th>GPA / NGPA</th></tr>
<tr><td colspan="2">4</td><td>CH2210</td><td colspan="2">Materials for Engineering Applications</td><td>C</td><td>GPA</td></tr>
<tr><th colspan="3">Hours/Week</th><th rowspan="2">Credits</th><th rowspan="2">Prerequisites / Corequisites</th><th colspan="2">Evaluation %</th></tr>
<tr><th colspan="2">Lecture</th><th>Lab/Tutes</th><th>CA</th><th>WE</th></tr>
<tr><td colspan="2">2</td><td>2</td><td>3.0</td><td>None</td><td>30</td><td>70</td></tr>
</table>

Learning Outcomes

After completing this module, students should be able to;

- LO1: *Understand* the structure, function, properties of materials used in industrial applications
- LO2: *Identify* the suitable materials for a given application
- LO3: *Recognize* the different types of material failures
- LO4: *Choose* appropriate corrosion preventing methods
- LO5: *Differentiate* the material treatment methods for engineering performance
- LO6: *Apply* the correct procedures for material selection

Syllabus Outline

Overview to materials used in Chemical Engineering Applications
Classification, types of materials and their properties.
Metals
Identification of metals (ferrous, non-ferrous, alloys) to suit a given application based on their properties and machinability.
Types of failures, failure mechanisms and prevention.
Non-destructive testing methods for metals.
Corrosion: types of corrosion, mechanisms, selection of appropriate corrosion prevention methods, application of the selected methods.
Surface treatment methods.
Ceramics
Properties and applications of ceramics.
Thermal treatments for ceramics.
Polymers
Advantages of polymer materials over traditional materials.
Classification of polymers: Natural and synthetic polymers.
Polymers (Elastomers, Plastics, Fibres, Thermoplastic Elastomers) used in the process industry, their structure-property relationships, and applications.
Polymer lattices, Composites, blends, and alloys.
Smart polymeric materials and advanced polymeric materials.
Additives used in polymer products.
Material Selection for Chemical Engineering Applications

Semester	Code	Module Title		C/E/O	GPA / NGPA
4	CH4501	Chemical Kinetics and Reactor Design		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
3	2	4.0	CH1061, CH1051, CH1044, CH2160, CH2631, CH2015	40	60

Learning Outcomes

On successful completion of this module, students are able to:

- LO1: *Recognize* the reaction scheme and determine the rate law
- LO2: *Understand* the theories of adsorption and apply them in controlling the rates of reactions
- LO3: *Design* batch reactors, plug flow reactors (PFRs), continuous stirred tank reactors (CSTRs) and catalytic reactors for the chemical and process industry
- LO4: *Determine* a suitable reactor or a system for an application or a condition
- LO5: *Analyze* chemical reactor performance using the distribution of residence times
- LO6: *Analyze* and determine the concentrations of the reactants and products at certain stages under given conditions

Syllabus Outline

Introduction to kinetics and reactor design, Industrial application of reactors, Analysis of continuous flow reactors and non-flow reactors.
Classification of chemical reactions, Rate laws, Determination of the order of a reaction, Influence of temperature on reaction rates and Arrhenius equation.
Multiple reactions, Molecular reaction dynamics:
Collision theory and Transition state theory.
Conversion and reactor sizing:
Design Equations for flow reactors, reactors in series.
Isothermal reactor designing:
Liquid phase reactions and gas phase reactions.
Steady state non isothermal reactor designing:
Adiabatic operations
Unsteady state non isothermal reactor designing:
Batch reactors, Semi-batch reactors, unsteady energy balance.
Physisorption and chemisorption, Adsorption isotherms (Langmuir, Freundlich), Non-competitive and nondissociative
Catalysis and Catalytic reactors, Definition, properties and classifications of catalysts, Steps in catalytic reaction
Homogeneous and Heterogeneous catalysts:
Synthesis, applications, regeneration, and troubleshooting. Chemical reactor performance using the distribution of residence times

Semester	Code	Module Title		C/E/O	GPA / NGPA
4	CH2270	Laboratory Practices II		C	GPA
Hours/Week (spread over two semesters		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
0	4	2.0	Prerequisites: CH2170 Corequisites: CH2151, CH2180, CH4501	100	0

Learning Outcomes

After completing this module, the student should be able to**:**

- LO1: *Apply* graphical construction techniques for process equipment.
- LO2: *Develop* 3-D models using a CAD package.
- LO3: *Apply* software tools to develop, simulate, and analyse mathematical models for reactors, separators, and heat exchangers.
- LO4: *Understand* the concepts and techniques relevant to applications in chemical and process engineering.
- LO5: *Apply* appropriate methods to plot, analyse and present experimental results, and verify principles when applicable.

Syllabus Outline

Laboratory Practices II module covers the practical aspects in applications of Chemical and Process Engineering (CH2151, CH2180, and CH4501) and provides in-depth learning for engineering drawing and computer aided chemical engineering.

Engineering Drawing and Computer Aided Learning

Complete engineering drawing of process equipment using computer aided drafting software (SOLIDWORKS®).
Property analysis of chemical system using Aspen Plus®; Thermodynamic property methods, property analysis of pure components/binary/mixtures, VLE curves x-y diagram, ternary maps.
Process flow sheeting, simulation of equipment models and simulation of chemical process using Aspen Plus®; Development of mathematical models for reactors, separators, and heat exchangers (Excel and MATLAB®).

Laboratory Experiments (8 Sessions)

(1) Pressure drops in a packed bed and fluidized bed. (2) Filter press/Demonstration on centrifuge, cyclone, coagulation, and sieve analysis. (3) Pressure-drop over a bubble cap plate; H.E.T.P Distillation, (4) Soxhlet Extraction. (5) Adsorption. (6) Evaporation. (7) Batch reactor/ Plug flow reactor. (8) Determination of specific rate constant for first order hydrolysis of ethyl acetate.

Semester V

Semester	Code	Module Title			C/E/O	GPA / NGPA
5	CH4045	Process Dynamics and Control			C	GPA
Hours/Week		Credits	Prerequisites / Corequisites		Evaluation %	
Lecture	Lab/Tutes				CA	WE
2	2	3.0	Prerequisites: CS1033, MA2014, MA3024 Corequisites: CH3034, CH3150		40	60

Learning Outcomes

After completing this module, students should be able to,

- LO1: *Describe* the behaviour of 1st, 2nd and higher order dynamical systems.
- LO2: *Analyze* linear dynamical systems using mathematical tools such as Laplace transforms etc.
- LO3: *Set up* simple feedback loops using PID controllers and development of control modules.
- LO4: *Implement* various PID tuning methods for controllers.
- LO5: *Design and Develop* feedback controllers with various control methods to eliminate disturbances.
- LO6: *Implement* and test out their controller designs by using simulations.

Syllabus Outline

Introduction to Process Dynamics & Control
Determine possible control objectives, input variables (manipulated and disturbance) and output variables (measured and unmeasured), and constraints (hard or soft), as well as classify the process as continuous, batch, or semicontinuous.
Dynamic Behaviour
Stability of Dynamic systems understand first-order, first order + dead time and integrating system step responses, Understand second-order under-damped behaviour, Routh Stability Criterion.
An Introduction to Laplace transformation
Transfer function, Definition of the Laplace Transform, Poles and zeros, Time constant and resonance, Zero dynamics. Transfer Function Analysis of First-Order Systems, Responses of First-Order Systems. Integrating Processes, Lead-Lag Models.
Introduction to Feedback Control
Development of Control Block Diagrams, Response to Setpoint Changes, Effect of Tuning Parameters, Response to Disturbances, Open-Loop Unstable Systems.
PID Controller Tuning
Closed-Loop Oscillation-Based Tuning, Tuning Rules for First Order + Dead Time Processes. The Direct Synthesis (DS) method, Internal Model Control (IMC), IMC-Based Feedback Design for Delay-Free Processes, IMC-Based Feedback Design for Processes with a Time Delay, IMC-Based PID Controller Design for Unstable Processes.
Cascade and Feed-Forward Control
Cascade-Control Analysis, Cascade-Control Design, Feed-Forward Control, Feed-Forward Control in the IMC Structure, Combined Feed-Forward and Cascade.
Various control methods and control structures
Ratio Control, Selective and Override Control, Split-Range Control.
Frequency-Response Analysis
Bode and Nyquist Plots, Effect of Process Parameters on Bode and Nyquist Plots, Bode and Nyquist Stability, Robustness.
Control-Loop Interaction
The General Pairing Problem, The Relative Gain Array, RGA and Sensitivity, Using the RGA to Determine Variable Pairings.
Plantwide Control
Steady-State and Dynamic Effects of Recycle, The Control and Optimization Hierarchy.
Fuzzy logic control system
Identification of variables, Fuzzy subset configuration, obtaining membership function, Fuzzy rule base configuration, Fuzzification, Combining fuzzy outputs, Defuzzification.

Semester	Code	Module Title		C/E/O	GPA / NGPA
5	CH3045	Plant Safety, Health and Environment		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
7/2	1	4.0	None	30	70

Learning Outcomes

On successful completion of this module, students are able to:

- LO1: *Describe* basic principles related to safety and loss prevention in chemical and process industry.
- LO2: *Understand* environmental pollution and related problems.
- LO3: *Describe* environmental pollution control and management.
- LO4: *Explain* principles of sustainability.
- LO5: *Discuss* basics of safety in plant site layout design, operation, maintenance and modification and basics. of incident reporting, investigation and management and legislative framework.
- LO6: *Identify* hazards in chemical and process industry.
- LO7: *Apply* appropriate techniques or measures to avoid or reduce hazards.
- LO8: *Analyse and evaluate* hazards in chemical and process industry.

Syllabus Outline

Introduction to plant safety, health, and environment
Toxicity and chemical safety
Fire and explosion hazards
Safety strategies:
Inherent safety, active, passive, and procedural safety
Identification of process hazards, principles of risk assessment and safety management:
HAZOP, event tree, fault tree
Personal protective equipment, Ergonomics, Industrial diseases
Noise and ventilation, thermal radiation
Plant layout design for safety, hazardous area classification, safety in plant operation, maintenance and modification, relief, and blowdown.
SHE incident and near miss reporting, investigation and management, human factors in safety
Toxic release and dispersion
Legal background:
Health and safety at work
Precautionary principle, responsible care
Introduction to environmental pollution:
liquid, gaseous, and solid pollutants, their sources, and characteristics
Introduction to environmental impacts
Environment related international agreements
Environmental Management Systems
Principles of engineering for sustainability
Environmental protection regulations
Introduction to waste minimization and pollutant treatment methods: at source and 'end-of-pipe'

Semester	Code	Module Title		C/E/O	GPA / NGPA
5	CH3034	Process Equipment Design		C	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
3	2	4.0	CH1044, CH1051, CH2015, CH2210	40	60

Learning Outcomes

After completing this module, student should be able to:

- LO1: *Understand* process equipment design philosophy, design codes, and standard formulae for economical and safe design of process equipment and auxiliaries
- LO2: *Explain* the operational principals of process measurement and instrumentation
- LO3: *Select* the design preliminaries and considerations, and auxiliaries for vertical and horizontal process vessels for safe design
- LO4: *Apply* mechanical design fundamentals for estimation of stresses in cylindrical process vessels, spherical and conical shells, and end closures
- LO5: *Calculate* safe thicknesses and requirements for compensation in openings for process equipment
- LO6: *Design* tall towers under combine loads and process vessels under external pressure to avoid their collapse
- LO7: *Apply* knowledge in Principals of Fluid Dynamics, Thermodynamics, and Heat transfer for economical and safe design of piping systems, turbines and compressors, and heat exchangers

Syllabus Outline

Mechanical design fundamentals

Bending moment and shear force, Bending stresses, Deflection, Buckling, Torsion, Impact loading and combined loading, General two-dimensional stress system, Principal stress and strain, Plain strain, Theories of failure, Analysis on failure criteria

Types of cylindrical shells and pressure vessels

Thin-walled cylinderical shells, Thin-walled spherical and conical shells, Volume changes of shells, Thick-walled cylinderical shells, Internal and external pressure vessels, end closures (flat, ellipsoidal, torispherical, and toriconical covers)

Mechanical design preliminaries and considerations for process equipment

Process equipment design codes, Structure of ASME boiler and pressure vessel codes, Classification of process equipment, Design pressure, Design temperature, Material Selection for process equipment, Design stress, Methodology, and procedure for mechanical design of process equipment, Welding types and efficiency, Safe design factors and allowances, Process equipment fabrication techniques

Internal Pressure Vessels Design

Mechanical design calculations for Thin walled and Thick-walled internal pressure vessels, Design of process equipment supports, Stiffener rings and auxiliaries, Compensation for openings, Anchor bolts, Vessel Installation

External Pressure Vessel Design

Mechanical design calculations for Thin walled and Thick-walled external pressure vessels

Design for combined loading on vessels and columns

Design calculations for pressure vessels under combined loadings, such as weight loads, wind loads, external loads due to varios factors

Mechanical design of pipes, turbo machines, and heat exchangers

Pipe schedule number, Safe pipe thickness calculations and economic pipe diameter, Mechanical design calculations for pumping requirements, Mechanical design awareness for gas turbines/compressors, TEMA design standards for tubular heat exchangers, Mechanical design awareness for heat exchangers

Process measurement and instrumentation

Measurement techniques and intrumentation for temperature, pressure, level, flow, and mass/force parameters in process equipment operations

Semester	Code	Module Title		C/E/O	GPA / NGPA
5	CH3055	Energy Systems Engineering		C	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	CH1051, CH1044, CH1061, CH2015	40	60

Learning Outcomes

After completing this module, the student should be able to:

- LO1: *Understand* the energy problem and identify the need for energy efficiency and conservation.
- LO2: *Analyze* combustion in steam and heating systems.
- LO3: *Identify* losses and evaluate the performance of energy systems.
- LO4: *Apply* recovery methods to the energy systems.
- LO5: *Analyze* energy systems by performing energy audits.
- LO6: *Evaluate* technical, environmental, and economic feasibility of energy projects.

Syllabus Outline

Introduction to industrial energy systems
Country and world energy balance, The energy problem, Need for energy efficiency and conservation in industrial energy systems.

Combustion in steam and heating systems
Fuel types, Combustion theory, Efficient combustion, Combustion equipment.

Industrial steam systems
System description (boilers, steam distribution system, steam end users, condensate return system), System and subsystems performance definitions.

Boiler subsystem - Boiler performance analysis (direct/indirect methods, boiler losses), Factors affecting boiler performance (boiler load, boiler design, fouling, controls, water quality), Performance improvement opportunities (combustion efficiency improvement, load scheduling, waste heat recovery, water treatment improvement, control improvement).

Steam distribution and condensate return subsystem - Performance analysis, Factors affecting the performance (steam leaks/heat transfer loss through insulation/condensate loss/flash steam loss), Performance improvement opportunities.

Heating systems
Types and classifications (Ovens, Furnaces, Kilns), Operation, Performance evaluation (direct/indirect methods, losses), Energy-saving and recovery opportunities.

Refrigeration systems
Chilling and chilled storage, freezing, deep freezing, cold storage, deep cold storage, vapor compression/absorption systems, performance definitions, factors affecting performance, performance analysis, performance improvement opportunities (maintenance, control, operational - load/temperature lift/superheat)

Compressed air systems
System description, Performance analysis (performance indicators, performance graph), Measurements, Leakage determination (load-unload test, pump-up test), Performance improvement opportunities

Industrial electric power systems
Description of industrial electric power systems, Basic terms, Tariff system, Main components of industrial electric power systems, Performance assessment of industrial electric power systems, Performance improvement opportunities (load management, demand control, power factor correction, electric motor drives).

Energy management
Main components, goals, and phases of energy auditing, Economic and environmental evaluation of energy projects

Semester	Code	Module Title		C/E/O	GPA / NGPA
5	CH3150	Chemical Process Synthesis and Integration		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	CH1061, CH1051, CH2015, CH2180, CH4501	40	60

Learning Outcomes

On successful completion of this module, students are able to:

- LO1: *Describe and Distinguish* process synthesis methods.
- LO2: *Conduct* process economics.
- LO3: *Understand* reactor and separator performances.
- LO4: *Select* reaction and separation systems.
- LO5: *Apply* pinch analysis to energy and capital targeting.
- LO6: *Evaluate* Utility Systems and heat integration of unit operations.
- LO7*: Design and optimize* heat recovery networks

Syllabus Outline

Introduction to process synthesis and Integration
Chemical products, Formulation of design problem, Process synthesis techniques, onion model, continuous and batch processes.
Process economics
Capital and operating costs, Simple economic criteria.
Selection of reactor and of separator, operating conditions, and configurations.
Reaction, separation and recycle systems for continuous and batch processes. Function of process recycling recycle with purging.
Introduction to Pinch Analysis
Data Extraction, heat recovery, Energy and capital cost targeting, Problem Table algorithm, Pinch principles, Grid diagram, Threshold problems.
Utility selection
Multiple utilities, Grand Composite Curves, Heat cascading, minimum approach temperature.
Heat Exchanger Network Design
Types of heat exchangers, Number of heat exchanger units, heat exchanger target area
Design HEN using pinch principles Loop Breaking, stream splitting.
Combined Heat and Power generations
Introduction to heat pumps and engines integration to process.
Heat integration of furnace,
Furnace efficiency, Capital energy trade off, Heat pipes, Recuperative and regenerative heat exchangers.
Heat Integration of reactors
Endothermic and Exothermic Reactors.
Heat Integration of Separators, Distillation Columns, Evaporators and Dryers
Apply software for design and optimization of heat recovery networks

Intake	2020	Specialisation	Chemical and Process Engineering		
Semester	**Code**	**Module Title**		**C/E/O**	**GPA / NGPA**
5, 6	CH3880	Engineer and Society		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tute**			**CA**	**WE**
1	4	3.0	None	100	0

Learning Outcomes

After completing this module, students will be able to**:**

- LO1: *Demonstrate* an understanding of the responsibilities of the engineering profession and its social context
- LO2: *Demonstrate* an understanding of the health, safety and environmental requirements of the society
- LO3: *Practise* with integrity in the social context of the engineering profession with an understanding of ethical issues
- LO4: *Identify and apply* appropriate tools/ techniques for the evaluation of health, safety and environmental hazards/ consequences and risk assessment
- LO5: *Interpret* the engineers' role in ethically assuring healthy, safe and excellent environmental conditions targeting the overall sustainable development of the society
- LO6: *Ability* to critique technology
- LO7: *Apply* the knowledge and skills gained of towards building character as a socially responsible professional engineer.

Syllabus Outline

(Content is indicative and specifics in sections may vary depending on the specialisation)

- Introduction to Engineering Ethics - Historical context, moral responsibility, IESL code of ethics, other relevant codes of ethics, community standards and personal responsibility, ethics of research and publication
- Ethics in the Society & Workplace - Respect for social & cultural values, respect for other professions, social responsibility, ethical decisions as individuals, identifying ethical issues, conflicting scenarios and problems in the field of engineering, leading organizations towards ethical behaviour
- Inclusive engineering concepts – ensuring that engineering products and services are accessible and inclusive of all users, and are as free as possible from discrimination and bias
- Legal requirements related to engineering practice – acts, ordinances and regulations
- Health & Safety – Definitions, areas and hazard identification, risk assessment, evaluation and management
- Health & Safety Management – Management practices, local regulations, global standard and best practices, designing of health and safety management systems, special topics
- Environment – managing the generation, transportation and disposal of waste in industry, overview of controlling and treatment technologies, local standards and EPL procedure, introduction to environmental impact assessment
- Ethical issues in emerging technologies
- Engineers' responsibility in sustainable development
- Case studies (industry specific)

Industrial Training

Semester	Code	Module Title		C/E/O	GPA / NGPA
Industrial Training	CH3994	Industrial Training		C	NGPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
-	-	6.0	None	100	0

Learning Outcomes

After completing this module, student should be able to,

- LO1: *Apply* knowledge and principles of chemical and process engineering.
- LO2: *Understand* industrial systems, procedures, practices, and professional ethics.
- LO3: *Design* solutions for industrial/engineering problems using modern tools and techniques.
- LO4: *Develop* soft skills and professional attitudes required for industrial environment.
- LO5: *Recognize* social, cultural, and environmental responsibilities as an engineer.

Syllabus Outline

Knowledge and principles of chemical and process engineering
Process analysis, Process plant operations/maintenance/troubleshooting, Energy efficiency and conservation, Health-Safety-Environmental aspects of chemical processes, Process instrumentation and software platforms for process control systems, Quality control/assurance and monitoring process parameters for process improvement/development, Process diagrams and engineering drawings.
Industrial systems, procedures, and practices
Administration/financial/general management/logistics/HSE/legal practices in an industrial organization, Practices of professional ethics/personal relations, Organizational practices for process efficiency improvement, Regulations and standards.

Semester VI

Semester	Code	Module Title		C/E/O	GPA / NGPA
6, 7, 8	CH4751	Research Project		C	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
-	6	3.0	None	100	0

Learning Outcomes

After completing this module, student should be able to:

- LO1: *Review* literature critically and identify research gaps/problem.
- LO2: *Develop* new experimental set ups/ models/strategies.
- LO3: *Develop* creative thinking and self-integrity under challenging environment.
- LO4: *Analyze* experimental/modelling results and draw conclusions.
- LO5: *Produce* research findings as a publishable material.

Syllabus Outline

Background study and problem identification

Literature review

Research proposal development

Design of experiments

Methodology development and experimental work/modeling and simulation

Data analysis and interpretation

Reporting and publication of results

Semester	Code	Module Title	C/E/O	GPA / NGPA
6	CH3170	Laboratory Practices III	C	GPA

Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
-	6	3.0	CH1051, CH2170, CH2270, CH2210, CH3045, CH3055, CH4045	100	0

Learning Outcomes

After completing this module, the student should be able to,

- LO1: *Develop* detailed drawings of process equipment.
- LO2: *Construct* P&I diagrams for chemical equipment and processes.
- LO3: *Analyse* chemical processes using process simulation tools.
- LO4: *Develop* numerical models of a process and build computer models for simulations by using computer aided tools.
- LO5: *Employ* advanced concepts and techniques relevant to applications in chemical and process engineering.
- LO6: *Apply* appropriate methods to plot, analyse and present experimental results, and verify principles when applicable.

Syllabus Outline

Laboratory Practices III module covers the application and design aspects in Chemical and Process Engineering (CH1051, CH2210, CH3045, CH3055, and CH4045) and provides in-depth learning for engineering drawing and advanced computer aided chemical engineering.

Engineering Drawing and Computer Aided Learning.

Detailed drawing of process equipment with auxiliaries (assembly drawing) using SOLIDWORKS®.
Development of P&ID using suitable software packages.
Advanced process analysis tools in Aspen Plus® (design specifications, calculator blocks, sensitivity analysis, optimization tools).

Challenge based project work.

Development of a numerical model of given process and analyse system dynamics by simulations. Develop suitable control structure to tight control of quality parameters and eliminate disturbances. Development of SIMULINK® and LabVIEW models to simulate the control structure to understand control behaviour.

Laboratory Experiments (8 Sessions).

(1) Rankine cycle, Steam analysis. (2) Corrosion (3) Identification of Polymers (4) Determination of properties of petroleum (flash point, fire point, aniline point, etc.). (5) COD, TS, TDS, TSS, and VSS of wastewater. (6) Determination of DO, residual chlorine, alkalinity, and pH. (7) Tuning PID controller for air heater (8) Introduction of ladder programming to control process engineering applications by PLC.

Semester VII

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4016	Comprehensive Design Project I		C	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
-	8	4.0	None	100	0

Learning Outcomes

After completing this module, student should be able to:

- LO1: *Develop* complex design problem-solving skills
- LO2: *Conduct* a design project with a significant degree of engineering competence
- LO3: *Apply* chemical synthesis and process synthesis techniques
- LO4: *Develop* process flow diagram and perform mass and energy balance
- LO5: *Perform* sustainability analysis for a process plant
- LO6: *Develop* skills on teamwork, technical reporting, and presentation

Syllabus Outline

Market Analysis:
Determine the suitable plant capacity
Chemical Synthesis of the process:
Select the chemical pathway based on gross profits using bulk material prices
Process Synthesis:
Identify the design tasks and the major units, identify other required units to eliminate the changes in temperature, pressure, composition, and phase
Process flow diagram:
Sequence the tasks with integrated unit operations ensuring energy recovery, develop the process flow diagram
Material and Energy Balance:
Select the unit basis and the system boundary, Detailed material and energy balance for the process, Material and Energy flowsheet
Sustainability Assessment of the process:
Environmental Sustainability: Top level Environmental impacts assessment, Leopold Matrix
Social Sustainability: Risk Assessment (e.g., Fault-tree analysis), Safety and Health Assessment (e.g., HAZOP)
Economic Sustainability: Cost-benefit analysis
Site selection and Plant layout:
Site selection: Based on Raw materials, Land, Transportation, Labor, Infrastructure facilities, Utilities, Government Policy, Safety and Environment, Sustainability requirements
Plant layout development

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4120	Biofuels and Biorefineries		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	CH1061, CH4501	40	60

Learning Outcomes

After completing this module, the student should be able to,

- LO1: *Understand* the basic concepts of biofuels and biorefinery.
- LO2: *Recognize* the applicability of chemical, biological and physical process technologies in conversion of biomass to biofuels and value-added chemicals.
- LO3: *Compare* technical and economic feasibilities among technologies.
- LO4: *Select* suitable technologies of trending biomass to biofuel/biochemicals or biomaterials conversions.
- LO5: *Appraise* suitable modular process systems for selected conversion technologies.
- LO6: *Design* modular process systems for biorefinery.

Syllabus Outline

Introduction

Definition, objective of biorefinery, feedstock classification, and composition, product range – Biofuels, Biomaterials, Biopolymers, platform chemicals and speciality chemicals, limitations, and impacts. Assessment on site-specific feedstock availability and identify potentials among different biomasses.

Feedstock for biorefinery

Physical and Thermochemical processes in biorefinery

Mechanical crushing, Ultrasound treatment, Microwave treatment, Liquefaction, Torrefaction, Pyrolysis, and Gasification

Chemical and Biological processes in biorefinery

Hydrothermal, Acid, and alkali pre-treatments/Catalysis /Hydrotreating/Anaerobic reactions

Characterization of properties of biofuels

Calorific values, fuel specifications, properties of blends

Characterization of other products

Matching biochemicals and biomaterials for industries

Techno-economic analysis of technologies, processes, and product range of biorefinery, Environmental management of biorefineries

Selection of feasible technologies, processes, and product range for Sri Lankan scenario:

Case-based unit

Design and Simulation of modular process systems

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4130	Process Optimization		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	CS1033, MA2014, MA3024, CH3034, CH4045, CH2180, CH1044, CH2015, CH4501	40	60

Learning Outcomes

After completing this module, students should be able to,

- LO1: *Describe* the nature and organization of optimization problems
- LO2: *Understand* optimization theory and methods
- LO3: *Identify* techniques of optimization and translates these concepts into computational methods and algorithms
- LO4: *Construct* process engineering models for optimization
- LO5: *Formulation* of the objective functions
- LO6: *Apply* optimization techniques to chemical and process engineering

Syllabus Outline

Formulating the problem

the nature and organization of optimization problems, Scope and Hierarchy of Optimization, The Essential Features of Optimization Problems.

Developing models for optimization

Classification of Models, Degrees of Freedom, Inequality and Equality Constraints in Models.

Formulation of the objective function

Economic Objective Functions, Efficiency Objective function, The Time Value of Money in Objective Functions, Measures of Profitability.

Optimization theory and methods

Basic concepts of optimization: Continuity of Functions, NLP Problem Statement, Convexity and Its Applications, Interpretation of the Objective Function in Terms of Its Quadratic.

Optimization of unconstrained functions: one-dimensional search, Numerical Methods for Optimizing a Function of One Variable, Scanning and Bracketing Procedures, Newton and Quasi-Newton Methods of Unidimensional Search, Polynomial Approximation Methods.

Unconstrained multivariable optimization: Methods Using Function Values Only, Methods That Use First Derivative, Newton's Method, Quasi-Newton Methods.

Linear programming (LP) and applications: Geometry of Linear Programs, Basic Linear Programming Definitions and Results, Simplex Algorithm, Sensitivity Analysis.

Nonlinear programming with constraints: Direct substitution, First-Order Necessary Conditions for a Local Extremum, Quadratic Programming, Penalty Barrier and Augmented Lagrangian Methods, Successive Linear Programming, The Generalized Reduced Gradient Method, Relative Advantages and Disadvantages of NLP Methods

Mixed-integer programming: Branch-and-Bound Methods Using LP Relaxations, Solving MINLP Problems Using Branch-and-Bound Methods, Solving MINLPs Using Outer Approximation.

Global optimization for problems with continuous and discrete variables

Methods for Global Optimization, Multi-start Methods, Heuristic Search Methods, Genetic algorithm.

Case studies

Applications of optimization, Optimization of Heat transfer and energy conservation process, Optimization of Separation processes, Optimization of Chemical reactor design and operation.

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4140	Biotechnology		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	None	40	60

Learning Outcomes

After completing this module, the student should be able to**:**

- LO1: *Appraise* the impact of biotechnology in society
- LO2: *Discuss and differentiate* biotechnology, bionanotechnology, and nanobiotechnology
- LO3: *Demonstrate* comprehensive knowledge and interdisciplinary skills in the field of biotechnology for synthesis of bioproducts and assessment of product quality
- LO4: *Categorize and use* techniques utilized to engineer cells and organisms for biotechnological applications
- LO5: *Design and develop* products and processes for medical and industrial applications using knowledge and transferable skills in biotechnology
- LO6: *Evaluate* the applicability of biotechnology to provide sustainable solutions for contemporary issues in science

Syllabus Outline

Engineering cells and organisms for bioprocesses:
Bio-based products and industries, cellular bioprocesses, DNA, gene expression, protein synthesis, recombinant DNA technology, mutagenesis, antisense technology, OMICS, bioinformatics

Enzyme technology:
Isolation and purification of enzymes, enzymes in medical applications, enzymes in process industries, immobilized enzymes

Biopharmaceuticals:
Introduction to pharmaceutics and pharmacology, biopharmaceuticals, fundamental bioprocesses and new technologies, economics of biomanufacturing pharmaceuticals, regulation and quality approaches, supply chain integrity of pharmaceuticals

Future medicine:
Drug delivery and therapeutics: Conventional medical devices, drug delivery, mechanical/electric-based and biological/cell-based therapies, gene therapy, and tissue engineering

Biomolecules for human use/consumption:
Biotechnological production of flavours, nutraceutical production

Analytical techniques in biotechnology:
Quantitative and qualitative analysis of bioproducts, analytical techniques and instrumentation for product analysis of biochemical/biological processes and metabolic activities

Biosensors and bioprocess control:
Biosensors in medical applications, biosensors in industrial applications, pathogen detection, biosensors in bioremediation

Vaccines and vaccine development pathways:
Viruses, pandemics and immunity, history of infectious diseases, basics of virology, immunology, and epidemiology, development of diagnostic tests, vaccines, and antiviral therapies

Bionanotechnology and nanobiotechnology:
Natural and incidental nanoparticles, engineered nanoparticles and their syntheses, applications of nanoparticles, biologically inspired nanostructures/biomimetics, industrial applications of biologically inspired nanostructures and materials, microfluidics

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4160	Process Chemicals Management		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	CH1071, CH4501, CH3045	40	60

Learning Outcomes

After completing this module, students should be able to:

- LO1: *Understand* the Importance of chemicals management in chemical and process industries.
- LO2: *Recognize* the national and international regulations on chemicals management.
- LO3: *Select and apply* the suitable chemicals management concepts, guidelines, and tools.
- LO4: *Demonstrate* the ability to develop a suitable chemicals management system for a process industry.
- LO5: *Discuss* the principals of green chemistry and its benefits.
- LO6: *Apply* the principles of green chemistry for process industry.

Syllabus Outline

Importance of chemicals management for the chemical and process industries

National and international regulations on chemicals management

Chemicals management concepts and tools

Main steps of lifecycle of chemicals

Techniques for chemical waste management and disposal

Chemical labelling systems

Applications of green chemistry principals

Case studies of green chemistry

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4371	Petroleum Trade and Economics		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	None	30	70

Learning Outcomes

After completing this module, the students should be able to,

- LO1: *Describe* economic perspectives of Oil and Gas Industry.
- LO2: *Evaluate* oil supply and demand and its effect on the industry.
- LO3: *Analyze* Transport, Processing and Sales Costs of Petroleum Processing.
- LO4: *Describe* trade practices pertaining to Petroleum Operations.
- LO5: *Select* best financial instruments for purchasing petroleum crude oil and diversifying product portfolio.
- LO6: *Design* operational procedures for techno-economic feasible operations in Petroleum Processing facilities.

Syllabus Outline

Introduction

A historical Perspective and present Oil and Gas Industry Overview

Oil and Gas Industry Markets

International standards, guidelines and directives related to oil and gas industry Including Exploration & Production

Effects of Regional Politics and Activities towards Petroleum Industry

Economic Trends in Petroleum Industry

Financial instruments used in Petroleum Industry

Techno-economic feasible operations in Petroleum Industry

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4410	Polymeric Materials		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	CH2210	30	70

Learning Outcomes

After completing this module, students should be able to:

- LO1: *Identify* the most suitable polymer/s for a given application.
- LO2: *Suggest* suitable analytical technique/s for identification of a polymer material or a product.
- LO3: *Select* reinforcing materials for a polymer composite.
- LO4: *Find* solutions to control the degradation of polymers.
- LO5: *Explain* the importance of using polymer blends and composites over a single polymer for specific applications.
- LO6: *Discuss* the importance of advanced materials used for selected applications.

Syllabus Outline

Overview of Polymeric Materials:
Elastomers, plastics, fibres, thermoplastic elastomers, lattices, and their uses
Polymer lattices (natural and synthetic) and characterization techniques
Polymers in packaging industry:
Food, pharmaceutical, cosmetic, electrical appliances
Polymers used in biomaterials
Polymer nanocomposites
Polymer Blends and alloys
Engineering Polymers:
High temperature polymers and high strength polymers
Matrix materials and reinforcing materials used in polymer composites
Advanced polymeric materials (conductive polymers, responsive polymers, hydrogels, liquid crystalline polymers)
Biodegradable polymers and their applications: poly (glycolic acid), poly(lactic acid), Nylon 2-Nylon 6, Polyhydroxybutyrate, polydioxanone (PDO)
Degradation and stabilization of polymers: Thermal degradation, photo degradation, oxidative degradation, ozone degradation and biodegradation
Analysis of polymeric materials: IR spectroscopy, UV spectroscopy, Nuclear magnetic resonance spectroscopy, Raman spectroscopy, Differential scanning calorimetry and Thermogravimetric analysis

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4026	Process Modelling and Simulation		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	CS1033, MA2014, MA3024, CH3034, CH4045, CH2180, CH1044, CH2015, CH4501	40	60

Learning Outcomes

After completing this module, students should be able to:

- LO1: *Describe* systems and models, main elements of dynamic modelling.
- LO2: *Identify* process parameters to develop a mathematical model of a system.
- LO3: *Construct* state space models and linearize non-linear systems.
- LO4: *Evaluate* dynamics of the systems and processes.
- LO5: *Develop* numerical models of a process and build up computer models for simulations by using computer aided tools (Python/MATLAB/SIMULINK).
- LO6: *Analyze* processes by using simulation studies.

Syllabus Outline

System and Model:
Main elements of Modelling of Dynamic Systems, General Form of Dynamic Models, Lumped Parameter Systems, Material and Energy Balances

Empirical model building:
Introduces Multi variable Model Identification, Theory and Applications of Distributed Systems for Momentum, Thermal and Diffusion processes

Linearization of the nonlinear Models:
The State-Space Formulation, Interpretation of Linearization, Solution of the Zero-Input Form, Solution of the General State-Space Form

Multiphase Systems with and without reactions:
Packed Bed Reactors, 1D and 2D Pseudo-Homogeneous Model, 1D and 2D Heterogeneous Model, Unsteady-State or Dynamic Models

Nonlinear systems analysis:
Generalization of Phase-Plane Behaviour, Nonlinear Systems- limit cycle behaviour. Introduction to Nonlinear Dynamics, A Simple Population Growth Model, A More Realistic Population Model, Cobweb Diagrams, Bifurcation and Orbit Diagrams

Artificial Neural Network–Based Models:
Artificial Neural Networks, Development of ANN-Based Models, Applications of ANNs in Chemical Engineering

Model Validation and Sensitivity Analysis:
Model Validation Methodology, Sensitivity Analysis, Direct Differential Method, Global Sensitivity Measures, Statistical analysis of mathematical models

Case Studies:
Biochemical reactor, Distillation process, Evaporation process

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4420	Waste Minimization and Resources Recovery		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	CH3045	30	70

Learning Outcomes

After completing this module, student should be able to:

- LO1: *Describe* waste management concepts relevant to the process industry.
- LO2: *Assess* cleaner production in the process industry.
- LO3: *Identify* source reduction and waste minimization opportunities and apply for waste management improvement of processes.
- LO4: *Select* resource recovery, recycling, and reuse techniques for waste.
- LO5: *Apply* process integration solutions for optimization of water consumption in the process industry.
- LO6: *Describe* circular economy theories and concepts in the process industry.
- LO7: *Analyze* existing and new processes for waste minimization, resources recovery and good manufacturing practices and waste management principles.

Syllabus Outline

Introduction to Waste Management Concepts
Extended producer responsibility, Product stewardship, Muda (Japanese term), Pay as you throw, Polluter pays principle, Resources recovery, Waste management hierarchy, 3R principle (Reduce, Reuse, Recycle), 5R Principle (Refuse, Reduce, Reuse, Repurpose, Recycle), Waste-to-energy, Zero waste.
Source Reduction and Waste Minimization
Resources recovery from waste
Recycling and Reuse techniques, Materials Recovery Facility (MRF), Composting, Pyrolysis, Incineration, Engineered landfilling.
Process integration solutions for waste avoidance
Water pinch calculations and water network design.
Concept of Cleaner Production and Cleaner Production Assessment
Good Manufacturing Practices (GMP)
Introduction to Circular Economy and Industrial symbiosis
Case Studies for waste minimization and resources recovery

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4430	Industrial Chemical Manufacturing Processes		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	None	40	60

Learning Outcomes

After completing this module, the student should be able to,

- LO1: *Understand* the production of chemicals and role in society
- LO2: *Identify* the Global Chemical Process Industry
- LO3: *Define* different Chemical Manufacturing Processes
- LO4: *Illustrate* product value chains (Global and local value chains)
- LO5: *Determine* Techno-economics of Chemical Manufacture
- LO6: *Assess* Environmental Management concepts of Chemicals Manufacture

Syllabus Outline

Introduction to Global Chemical Process Industry (CPI)
Chemicals and their role in society
Inorganic chemicals manufacture
Phosphorous, Phosphates and Fertilizers
Sea based chemicals
Salt, Chlor – Alkali and Related Heavy Chemicals
Industrial Gases and Speciality gases
Industrial Acids
Sulphuric, Hydrochloric, Nitric, HF
Organic Chemicals Manufacture
Speciality fine chemical manufacture
Pharmaceuticals
Oleochemicals
Soap, fatty acids, and synthetic chemicals
Natural products manufacture
Dairy products manufacture
Techno economics of process operations in chemicals manufacture
Environmental Management aspects of chemicals manufacture

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4235	Polymer Processing Operations		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	None	30	70

Learning Outcomes

After completing this module, students should be able to

- LO1: *Identify and describe* the polymer processing operations related to rubber and plastic processing.
- LO2: *Discuss* the influence and importance of processing parameters on polymer processing operations.
- LO3: *Apply* rheological and heat transfer principles to optimize the polymer processing operations.
- LO4: *Recognize* the machineries used in polymer processing.
- LO5: *Analyze* products defects that can be appeared during respective polymer processing operations.
- LO6: *Demonstrate* the ability to select the most appropriate processing technique(s) for a desired polymer product to manufacture.
- LO7: *Apply* good manufacturing practices.

Syllabus Outline

Polymers and their thermal transitions

Polymer Rheology and Processing characteristics

Non-Newtonian behaviour of polymer melts; Processing characteristics: Viscosity, melt flow, rheological properties.

Heat transfer in Polymer systems

General equation of conduction; Steady and unsteady state heat conduction, convection, and radiation heat transfer applications.

Concentration of latex; Products manufacturing techniques (dipping, casting, foaming, spraying, extrusion)

Manufacture of different grades of raw rubber.

Mixing and compounding technologies.

Shaping/forming techniques for rubbers and plastics

Moulding processes: Compression moulding, Transfer moulding, Injection moulding, Reaction injection moulding, Blow moulding; Extrusion and Calendaring

Curing techniques

Batch and continuous curing processes.

Machine operations, process variables and their effects on product quality

New trends in polymer products manufacturing

3D printing

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH3253	Environmental Bioengineering		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	None	30	70

Learning Outcomes

After completing this module, student should be able to,

- LO1: *Understand* basic principles of biological wastewater treatment.
- LO2: *Explain* the microbial conversion processes and operating parameters.
- LO3: *Describe* microorganisms according to energy source and carbon source.
- LO4: *Evaluate* biological systems by applying microbial kinetics.
- LO5: *Develop* mathematical models and simulate bioreactors.
- LO6: *Design* bioreactors.

Syllabus Outline

Classification of microorganisms
Based on metabolic function.
Microbial growth kinetics
Biomass growth rate; rate equations.
Biological wastewater treatment principles
Identification of constituents in wastewater and basic parameters; aerobic and anaerobic process; nitrification, denitrification and phosphorus removal.
Types of bioreactors and activated sludge process
Bioreactor classification and their functions; Activated sludge process.
Introduction to bio process modelling
Mass and energy balance for bio reactors, design equation derivation; process matrix; balance growth reactions.
Bioprocess modelling tools
Modelling and simulation using related software tools.
Environmental Bioengineering Case Studies
Industrial based case studies.

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4440	Petrochemical Process Operations		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3	None	30	70

Learning Outcomes

After completing this module, the student should be able to,

- LO1: *Describe* key operations in petrochemical processes.
- LO2: *Demonstrate* petrochemical conversion pathways.
- LO3: *Analyse* petrochemical conversion technologies.
- LO4: *Apply* petrochemical conversion technologies to petroleum resources and economy in Sri Lanka.
- LO5: *Design* and evaluate of a process flow diagram for petrochemical conversion process.

Syllabus Outline

Introduction to petrochemical industry

A brief overview of petrochemical technologies and discuss upon the general topology of the petrochemical process technologies.

Resource identification and evaluate potentials in Sri Lanka

Evaluating the unique position Sri Lanka currently in the petrochemical industry, especially Hambantota is becoming a petroleum processing zone.

Petrochemical conversion pathways

Discuss the chemistry behind the major conversion options used in industry and discuss novel strategies to maximize economical gains.

Petrochemical processing pathways

Discuss process engineering fundamentals behind the major conversion processes including pre-treatment processes on petroleum streams as feedstock for petrochemical manufacturing plants.

A case study on design and simulation of a petrochemical conversion process

A selected petrochemical process will be discussed for optimization of operating parameters and mitigation of environmental and health risks involved.

Semester	Code	Module Title		C/E/O	GPA / NGPA
7	CH4285	Food Safety and Hygienic Plant Design		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	None	40	60

Learning Outcomes

After completing this module, the student should be able to**:**

- LO1: *Develop* an awareness on the modern food chain.
- LO2: *Identify* food hazards and necessary control mechanisms to improve hygienic food manufacturing.
- LO3: *Understand* the regulatory requirements for hygienically design processes.
- LO4: *Design* plants and equipment in compliance with standards and guidelines for hygienic design.
- LO5: *Evaluate* food safety management systems and recommend the preventive measures.

Syllabus Outline

Introduction:
Food safety key concepts (hazard, risk, hygiene); Evolution of hygiene in food plant design and operation; Supply chains in the food industry-bottlenecks and issues

Risks-Origin and Nature:
Food hazards-biological, chemical, and physical: prevalence, characteristics, contemporary monitoring methods, and control mechanisms

Hygienic Building Design Essentials:
General design issues for factory interiors; Site selection and plant layout; Significance in segregation/zoning; Hygienic design of walls, ceilings, and floors; Hygienic design of selected fixtures, utility systems and process support systems; Control of air borne contamination (source and control systems)

Hygienic Equipment Design Essentials:
Key criteria in hygienic equipment design: risk assessment and regulatory requirements; Hygienic design of different types of equipment (closed, heating, dry matter handling, electrical, packaging, piping systems, seals, valves, pumps, etc.)- construction materials, minimum design essentials, cleaning regimes, improved hygienic control by sensors, and future trends

Hygienic Plant Operations I-Verification and certification of hygienic food processing plants:
HACCP: HACCP steps, identification of potential hazards, identify CCP, establish CCP, establish monitoring procedures, establish corrective actions, record keeping procedures, verification; other quality systems (ISO 22000)

Hygienic Plant Operations II-Good manufacturing practices (GMP):
Effective manufacturing operations and risk control; Use of standard operating procedures (SOPs); Managing risks (allergenic residue, insects, personal hygiene, food transportation); Cleaning, Disinfection, and Sanitation [Cleaning kinetics and mechanisms; Cleaning of raw material, plants, and equipment (CIP and COP), packaging, odour abatement; enzymatic cleaning]

Semester VIII

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4035	Comprehensive Design Project II		C	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
-	10	5.0	CH4016	100	0

Learning Outcomes

After completing this module, student should be able to:

- LO1: *Appraise* key decisions to be made and relevant assessment criteria for equipment selection
- LO2: *Design* a selected process equipment in detail, including chemical, mechanical and operational aspects
- LO3: *Identify* the type of material and method of fabrication suitable for the equipment.
- LO4: *Select* control schemes and instrumentation.
- LO5: *Describe* the startup, shut down, operational, and maintenance procedure.
- LO6: *Analyze* safety and economic aspects of the equipment.
- LO7: *Develop* technical report writing and drawing skills.

Syllabus Outline

Chemical Design
Introduction of design problem including the design duty and design constraints; Review of alternative options for selecting the suitable process equipment; Chemical design calculations; Design specifications required for mechanical design, P & I, and process safety.

Mechanical Design, Process Control, and Process Instrumentation
Mechanical design calculations of major unit, accessories and supports; Mechanical drawings of major unit and components; Design of the control structure for the process unit; P & I diagram and Specifications of required instruments.

Process safety, Operation, and Costing
Conduct hazard and operability study (HAZOP) and identify and analyze problems that may represent hazards to personnel or equipment; Devise startup – shutdown procedure, maintenance schedule and troubleshooting plan; Costing of the complete unit including instrumentation.

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4275	Polymer Products Manufacturing Technologies		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	CH4235, CH4410	40	60

Learning Outcomes

After completing this module, students should be able to,

- LO1: *Identify* the components in an industrial rubber product to satisfy service requirements.
- LO2: *Apply* knowledge gain on polymer technology to optimize the manufacture of polymer products.
- LO3: *Understand* the manufacturing technologies used in polymer industry.
- LO4: *Assess* the properties of polymer products and to demonstrate testing procedures.
- LO5: *Recommend* recycling technologies to minimize pollution due to polymer waste.
- LO6: *Apply* the knowledge to maintain the required quality of products.

Syllabus Outline

Features and assemblies of commodity and engineering rubber products
(tyres, hoses and tubing, belts, sheaths, footwear, bearings, mounts, gaskets and seals, flooring and roofing products, etc.).

Additives used in polymer products manufacturing
Importance, functions, and limitations of, fillers, vulcanizing systems, processing aids, extenders and diluents, protective agents, dyes and pigments and speciality additives.

Manufacturing technologies used in pneumatic and solid tyres

Manufacturing technologies of gloves, foam and cast products

Fibre manufacturing technologies

Manufacture of extrusion-based products and moulded

Other Manufacturing technologies
Thermoforming and vacuum forming.
Manufacturing technologies of polymer composites.

Recycling and upcycling technologies.

Quality assurance aspects in polymer products manufacturing

Product testing and Characterization
Physical, chemical, thermal, electrical solution, and weathering properties

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4742	Polymer Products and Tool Design		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	CH4410	40	60

Learning Outcomes

After completing this module, students should be able to,

- LO1: *Identify* the important engineering principles applicable to design of polymer products and tools.
- LO2: *Identify* failure mechanisms of polymer products used under different service environments.
- LO3: *Describe* assembly techniques required for designing and manufacturing of polymer products.
- LO4: *Design* of simple engineering polymer products.
- LO5: *Design* simple injection mould/die to manufacture polymer product.
- LO6: *Recognize* the software used for design and fabrication of moulds for polymer products.

Syllabus Outline

Rubber elasticity and viscoelastic properties

Molecular requirements of rubber-like elasticity, Force as a function of deformation, temperature and network structure, Strain-induced crystallization, Boltzmann superposition principle, Time-temperature superposition principle, Stress-relaxation and creep, Dynamic mechanical behaviour, Models of viscoelastic behaviour, Effects of molecular structure on viscoelasticity.

Modes of deformation and Failure mechanics

Failure Modes, Fracture Modes, Fracture Toughness, Stress Concentrators (Flaws), Crack Propagation, Fracture of Polymers, Fatigue Curves for Polymers.

Design of rubber products

Important factors considered on designing of rubber products, Features and assemblies of commodity and engineering rubber products, basic calculation on designing of simple engineering rubber products.

Design of Plastic products

Design approaching methods, general considerations for designing injection moulded plastic parts, designing with plastics for electrical properties, design of plastic product s for mechanical assembly and welded assembly.

Design of Injection Moulds

Standard mould parts, two plate mould tool, multiplate tool system, Undercut Injection Mould Tools, Runner less Moulding. Design Checklist, Design of feed system, Design of Ejector System , Cooling system and venting system, Design of core and cavity, Mould making Techniques, Mould Materials.

Design of extrusion dies

General constructional features of Split, threaded, integer and plate dies, Die and screw characteristics, operating point, head pressure and total volumetric flow rate from extruder-die combination,

Design of extruder dies for extrusion of hollow profiles; slit dies for flat film and sheet extrusion, circular and non-circular solid profiles.

Computer aided design analysis and fabrication of moulds

Computer Aided Design Analysis and Fabrication of Moulds: Solidworks® mould tool design, Autodesk® Simulation Moldflow®, plastic injection moulding simulation software, Computer-aided manufacturing (CAM).

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4450	Energy Storage Systems		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	CH1051, CH2631, CH1044	40	60

Learning Outcomes

After completing this module, the student should be able to,

- LO1: *Identify* available energy storage technologies
- LO2: *Assess* the demand of energy storage for embedded generation
- LO3: *Apply* suitable energy storage technologies
- LO4: *Assess* the economic viability and conversion efficiencies of different energy storage technologies
- LO5: *Design* energy storage systems

Syllabus Outline

Introduction

Overview of energy storage concepts, Need of energy storage in renewable energy, Limitations and impacts of energy storage technologies.

Thermal energy storage

Sensible heat storage, Latent heat storage (phase change materials), Thermochemical energy storage (reversible reactions), Material selection, Application-specific constraints, Design of thermal energy storage for utility-scale renewables particularly for solar and geothermal power.

Electrochemical energy storage

Battery system structure, Elementary principle, Different types of batteries, Battery Management Systems, Aging of electrochemical batteries, Design of battery bank and economic evaluation for intermittent renewable energy systems.

Chemical energy storage

Concepts of power-to-gas and power-to-liquid, Efficiency and cost of fuel production, storage, transport, and electrical restitution, Comparison of different power-to-fuel pathways.

Mechanical energy storage

Concepts of pumped hydro, compressed air, flywheel.

Electrical energy storage

Concepts of energy storage in capacitors, ultracapacitors, and supercapacitors, Comparison of magnitude and quality of energy stored.

System integration of energy storage solutions with power generation units and grid management

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4255	Renewable Energy		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	CH1051, CH1044, CH1061	40	60

Learning Outcomes

After completing this module, the student should be able to,

- LO1: *Identify* renewable energy resources.
- LO2: *Describe* principles of renewable energy technologies.
- LO3: *Analyse* the applications of renewable energy technologies in domestic, industrial, and utility-scale.
- LO4: *Apply* modelling and simulation tools to analyse renewable energy technologies.
- LO5: *Evaluate* site-specific techno-economic-environmental viability of renewable energy technologies.
- LO6: *Design* optimal renewable energy systems that meet specific energy demands.

Syllabus Outline

Introduction
Overview of renewable energy concepts.

Wind energy
Wind resource identification and assessment, Conversion technologies and principles, Wind power applications.

Hydel energy
Hydro resource identification and assessment, Conversion technologies and principles, Pico/Micro/Mini hydro energy applications.

Solar energy
Solar resource identification and assessment, Solar PV/solar thermal conversion technologies and principles, Solar PV/solar thermal applications in different scales.

Biomass energy
Biomass resource identification and assessment (special focus to energy crops), Conversion technologies and principles, Biomass combustion/gasification/pyrolysis applications in different scales.

Micropower design and optimization using software tools
Design and optimization based on site-specific technical potential, levelized cost of energy, and environmental impact.

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4651	Combustion Technology		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	CH1051, CH 1044, CH2631, CH2015, CH4501, CH3055	40	60

Learning Outcomes

After completing this module, the student should be able to:

- LO1: *Understand* the fundamental concepts in combustion.
- LO2: *Determine* the factors influencing the flame speed and the flame thickness of laminar premixed flames.
- LO3 *Use* the conserved scalar formalism to understand and explain non-premixed behaviour.
- LO4: *Estimate* the droplet evaporation and burning rates.
- LO5: *Use* turbulent combustion concepts to characterize combustion regimes.
- LO6: *Apply* fundamental concepts in solid combustion to develop simple models of the burning of a carbon particle.
- LO7: *Apply* methods used to quantify the pollutant emissions from combustion systems.

Syllabus Outline

Introduction to combustion
Motivation to study combustion, definition of combustion, combustion modes and flame types

Review of prerequisites
Chemical thermodynamics and equilibrium - Mass, energy and atomic species conservation; Multispecies equilibrium and calculation method

Chemical kinetics - Principles of chemical kinetics (law of mass action and activation energy); Hydrocarbon reaction chains; Pollutant formation, Multistep reactions and explosions; Steady state and partial equilibrium approximations; Characteristic time and space scales

Applications of chemical kinetics - limit reactors
Common approximations in combustion analysis (Static reactor, Perfectly stirred reactor, Plug flow reactor); Thermal explosions; Autoignition

Heat, mass and momentum transfer in combustion - molecular and convective fluxes: Characteristic non-dimensional numbers: Dahmköhler, Lewis, Schmidt, Prandlt, Peclet, Reynolds

Pollutant emissions
Combustion generated pollutants; Effects of pollutant; Quatification of emissions; Emissions from premixed combustion; Emissions from non-premixed combustion

Laminar premixed flames
Laminar premixed flames: concepts and measurements; Characteristic time and space scales, Zeldovich number; One-dimensional conservation equation and simplified solutions; Effects of mixture composition, stretch and curvature

Laminar non-premixed flames
Laminar diffusion flames: concept and measurement methods; Characteristic time and space scales; Conserved scalars and mixture fraction; One-dimensional conservation equations: co-flow and opposed flow; Limit case solutions; Effect of mixture composition and fluid dynamics

Droplet evaporation and burning
Applications involving liquids combustion; Closed form analytical solutions to the simplified governing equations applicable to droplet evaporation and burning; Influence of droplet size and ambient conditions on droplet evaporation and burning; Droplet gasification rates and droplet lifetimes; One dimensional analysis of a simple, steady flow, liquid-fuel combustor

Turbulent flames:
Characteristic time and space scales; Regimes of turbulent combustion; Measurement methods and results; Approaches to modelling turbulent combustion; Turbulent premixed flame characteristics; Turbulent diffusion flame characteristics; Approaches to turbulent combustion theory

Burning of solids:
Applications involving solids combustion; Fundamental concepts in solids combustion: heterogenous reactions and simplifications; Burning of carbon: one-film model, two-film model; particle burning times; Coal combustion

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4215	Environmental Engineering and Management		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	CH3045	30	70

Learning Outcomes

After completing this module, student should be able to:

- LO1: *Identify and describe* environmental pollutants management techniques.
- LO2: *Apply* environmental accounting in project analysis.
- LO3: *Apply* mathematical models to simulate pollution control and treatment operations
- LO4: *Assess* environmental impacts.
- LO5: *Design* pollution control equipment and processes.

Syllabus Outline

Wastewater Engineering:
Treatment levels, physical and chemical treatment operations, biological (Up flow anaerobic sludge blanket (UASB), membrane bio reactors) and advanced treatment processes.
Air Pollution Control:
Particulate and gaseous pollutants control equipment and processes.
Solid Waste Management:
Integrated solid waste management, collection, treatment, and disposal.
Hazardous Waste Management and Engineering:
Hazardous waste treatment and disposal.
Environmental Impact Assessment:
Procedure and methods
Basics of Environmental Accounting:
Environmental valuation techniques and project analysis

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4460	Sustainable Process Technology		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	CH3045	30	70

Learning Outcomes

After completing this module, student should be able to:

- LO1: *Describe* the characteristics of sustainable process technologies.
- LO2: *Apply* life cycle thinking for products and processes in the process industry.
- LO3: *Evaluate* energy flows of process life cycle and interpret them for energy sustainability.
- LO4: *Select* processes and technologies based on environmental sustainability.
- LO5: *Evaluate* carbon footprint and water footprint of products and processes.
- LO6: *Analyze* environmental impacts of products and process life cycle stages.

Syllabus Outline

Introduction to Sustainable Process Technologies and Strategies to determine sustainability of processes
Process and Technology Selection
Life Cycle Thinking of Products and Processes:
Product life cycle, Process life cycle, and ways to define a life cycle scope of a given product or process (cradle-to-grave, cradle-to-gate, cradle-to-cradle, gate-to-gate scopes)
Energy Sustainability Assessment of Processes:
Energy Flow Analysis, Sankey Diagrams, Energy Sustainability Indicators for Processes
Carbon Footprint Assessment
GHG emission reductions or removal enhancements:
Procedure and Techniques
Water Footprint Assessment
Eco-Design and greening the supply chain:
Raw material extraction, manufacturing, transportation, use and end-of-life stages of a process.
Life Cycle Assessment (LCA) Methodology:
Goal and scope definition, System boundary, Functional unit, Allocation rules, Introduction to life cycle inventory and databases, life cycle environmental impact (LCIA) categories, LCIA methods, Interpretation methods of LCA results, Introduction to LCA software tools
Basics of Social LCA and Life Cycle Costing
Case Studies for Sustainable Process Technologies and LCA

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4351	Up-stream Oil and Gas Operations		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	None	30	70

Learning Outcomes

After completing this module, the student should be able to,

- LO1: *State* the scope of the upstream petroleum processing and describe key operations in the petroleum rigs and carriers.
- LO2: *Describe* composition, characterization, and classification of crude petroleum.
- LO3: *Understand* characteristics of good Reservoir Rock and Exploration Tools and Method
- LO4: *Implement* technologies for enhanced oil and gas production and onsite processing natural gas.
- LO5: *Analyse* problems in upstream processing operations and partial / full shutdowns.
- LO6: *Apply* modelling and simulation tools to identify causes and solutions for problems.
- LO7: *Design* optimal process units for oil and gas recovery processes and transport operations in crude oil rigs and carriers.

Syllabus Outline

Introduction
Upstream petroleum processing and key operations in the petroleum rigs and carriers.
Analysis of crude petroleum
Composition and Characteristics of crude petroleum.
Production of crude oil
Formation, Exploration, Drilling and Recovery methods of crude.
Separation of produced fluids
Two-phase gas oil separation, Three-phase oil water gas separation.
Treatment of produced fluids
Emulsion treatment and Dehydration of crude oil, desalting of crude oil, Crude oil stabilization and sweetening, Storage tanks and other field facilities, Produced water treatment.
Field processing and Treatment of natural gas
Overview of gas field processing, Sour gas treating, Gas dehydration, Separation, and Fractionation of Natural Gas Liquids.
Cryogenics Processes and Gas Compressors in Gaseous fuel Processing
HSE Management in crude oil rigs and carriers

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4381	Petroleum Refining Operations		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	None	30	70

Learning Outcomes

After completing this module, the students should be able to,

- LO1: *State* the scope of the downstream petroleum processing and describe key chemical processes in the petroleum refinery process.
- LO2: *Identify* functionalities of production processes and technologies in production of hydrocarbon fuels based on their applications.
- LO3: *Schedule* production routes & processes for the synthesis of petrochemicals and their derivatives.
- LO4: *Analyse* problems in petroleum processing operations and partial / full shutdowns.
- LO5: *Apply* modelling and simulation tools to identify causes and solutions for problems.
- LO6: *Design* optimal process units for production processes in petroleum refineries.

Syllabus Outline

Introduction Subsurface Operations of Oil & Gas Production

Characterization of Petroleum

Application based Petroleum Products Characterization – Automobile, Power generation, and other applications.

Refinery Processing of Oils and Gasses

Polishing & Conditioning Processes in liquid fuel processing & Gaseous Fuel Processing.

Product Handling & Storage in Oil and Gas Processing

Utilities Management in Oil & Gas Process Facilities & HSE Management in Petroleum Production Facilities

Problems in in petroleum processing operations and partial / full shutdowns

Modelling and simulations of major chemical processes in petroleum refineries

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4294	Bioengineering		E	GPA
Hours/Week		**Credits**	**Prerequisites / Corequisites**	**Evaluation %**	
Lecture	**Lab/Tutes**			**CA**	**WE**
2	2	3.0	None	40	60

Learning Outcomes

After completing this module, the student should be able to:

- LO1: *Identify, recognize, and appreciate* engineering contributions in bioengineering applications
- LO2: *Quantify* kinetics of microbial growth and enzyme action
- LO3: *Use* tools of bioprocess engineering
- LO4: *Design* key aspects of an industrial-scale fermenter
- LO5: *Evaluate* performances of a bioreactor
- LO6: *Troubleshoot* operational problems in bioprocessing

Syllabus Outline

Upstream processing
Introduction to upstream processing, isolation, preservation, and improvement to industrially important microorganism

Cell cultivation
Microbial, animal and plant cell cultivation and growth requirements, inoculation and culture media, selection and design of media for specific function, quantitative aspects of microbial growth and product formation

Microbial growth kinetics
Growth cycle for batch cultivation, growth models for batch, plug flow and continuous bioreactors. estimation of mono-kinetic parameters, productivity optimization and cell recycling

Enzyme kinetics
Introduction to enzyme reactions, Mechaelis–Menton approach and Briggs-Haldane approach, enzyme reactor types and enzyme inhibition

Sterilization
Sterilization of fermentation media and air, sterilization kinetics, process design

Bioreactors – selection, design, operation
Modes of operation, types of reactors, design of agitated bioreactors, measurements, instrumentation, and control, mass transfer concepts, power consumption, design of aeration and agitation systems, scale up strategies and criteria

Recovery and purification of bio-products
Process selection and design

Tissue Engineering
Need, challenges, and evolution; cell sources and culturing; scaffolds; the way forward

Semester	Code	Module Title		C/E/O	GPA / NGPA
8	CH4691	Food Process Engineering		E	GPA
Hours/Week		Credits	Prerequisites / Corequisites	Evaluation %	
Lecture	Lab/Tutes			CA	WE
2	2	3.0	None	40	60

Learning Outcomes

After completing this module, the student should be able to,

- LO1: *Explain* the mechanisms of spoilage and deterioration of foods and raw materials.
- LO2: *Describe* the role and function of packaging materials in food preservation.
- LO3: *Relate* food quality (texture, sensory, structure, etc.) to the chemical composition, processing, and storage conditions.
- LO4: *Develop* simple understanding on nutrition and dietetics and explain the effects of processing steps on nutritional quality.
- LO5: *Evaluate* common food processing techniques and preservation methods for safe and quality food production.
- LO6: *Calculate and model* different thermal technologies.

Syllabus Outline

Introduction to Food Processing

Food is Life; Evolution of Food Industry from Make-Service-Care; Properties of Food Material (mechanical, thermal, electrical properties, structure, water activity, phase transition phenomena in food).

Impact of food processing on nutritional quality

Nutrient value of different types of food; Role of nutrients; Food energy; Food processing and effect of unit operations on nutritional quality.

Food Engineering Operations

Preparative Operations; Structuring Processes (crystallization, glass transition, extrusion, emulsification, fat replacement); Separation Processes (freeze drying, freeze concentration, drying, membrane separation).

Food Preservation and Shelf-life I

Farm to mouth interactions, stakeholders; Mechanisms of food spoilage (microbial, enzymatic, chemical, physical); Food Preservation Processes; Minimally processed food (need, techniques, hurdle technology).

Food Preservation and Shelf-life II

Thermal Processing of Food [Thermal process parameters; Kinetics of thermal inactivation of MOs and enzymes; Lethality; Optimizing thermal processes for safe and quality foods; Current and emerging thermal technologies and equipment]; Low Temperature Operations [Chilling and Freezing; Factors affecting rate of freezing; Freezing time calculations; Properties of frozen food; Equipment and Methods]; Nonthermal preservation processes [Ionizing irradiation; High hydrostatic pressure preservation; Pulsed electric fields, Ultraviolet light and pulsed intense lights, Ultrasound treatment, Ozonation, Cold Plasma]; Chemical Preservation [Chemical control of spoilage (kinetics and antimicrobial agents); Antioxidants]; Biological Preservation [Fermentation and enzymes in food industry; Biopreservation].

Food Packaging

Factors governing the type of packaging and kinetics of packaging; Packaging materials; Atmosphere in the Packaging; Smart packaging.

What's Cooking-Trends in Food Engineering

Food mega trends; Functional foods; Food enrichment with natural ingredients; Probiotics and prebiotics; Nanofoods and Nanobiotechnology in food processing; 'Enginomics'.